THE

AMERICAN NATURALIST

VOL. XLI *September, 1907* No. 489

THE STRUCTURE OF CILIA, ESPECIALLY IN GASTROPODS

LEONARD W. WILLIAMS

WE venture to present the following incomplete observations in the hope that they may contribute to the solution of the difficult problem of the structure of cilia.

While looking over fresh marine plankton from Narragansett Bay, we came upon an unidentified but common larva of a protobranch mollusk whose velar cilia were so large that they were exceptionally favorable for study. With a cover glass upon the larva, we were able to watch with increasing ease the successive ciliary waves which gradually became less frequent and rapid as the animal died; and consequently we were able to study the individual cilia in detail. A groove with overhanging edges follows the rim of the velum, and the large preoral cilia are arranged in a row along the posterior edge of this groove. Each cilium is large and somewhat curved, being concave on the side toward which the effective stroke is directed. It tapers evenly from its basal body to its apex. The protoplasm at the base of the cilium was seen to contract alternately on the opposite sides of the basal body and, correspondingly, to move the base of the cilium back and forth. In contracting, the protoplasm draws the cuticula downward.

As already stated, the cilia are arranged in a row along the edge of a groove. The contraction of the protoplasm upon the lower side of the cilium draws its base into the groove while the lower portion of the cilium is bent so as to fit into the groove and the upper portion is carried backward a few degrees (Fig. 1, *a* and *b*). The convex side of the cilium is thus drawn into the groove. The

contraction of the protoplasm above the cilium carries its base upward, and cramps the cilium against the overhanging edge of the groove until the lower portion of the cilium is bent into an S-shaped curve (Fig. 1, *c* and *d*). The contraction continuing, the cilium is forced past the edge of the groove and flies out and back with a very rapid stroke — the effective stroke of the cilium (Fig. 1, *e*). It is carried by the force of its stroke far beyond its position of rest to which its elasticity brings it back in position for another stroke. There seems no doubt that these cilia are elastic rods (Fig. 2, *g*) which are moved by the contraction of the protoplasm at their bases. The cuticula around the base of the cilium rises and falls with the movement of the cilium as though it formed a plate into which the cilium is set. Consequently it appears that the contractile fibrillae of the protoplasm are inserted in the cuticula and not directly in the base of the cilium. We do not know what part the basal body plays in this movement but we believe that it forms a pivot upon which the cilium turns somewhat as an echinoderm spine turns upon its base.

The cramping and subsequent escape of the cilium account for the rapidity and force of the effective stroke and also explain the well known fact that the cilia of rotifers and veligers always seem to move only in the opposite direction to that which is necessary, since the effective stroke is too rapid to be visible. We do not believe that the groove is a common ciliary structure,— on the contrary it is probably present only in cilia like those mentioned, whose effective stroke is invisible. However, we should call attention to the pits, collars, and ridges at the bases of the flagella and cilia of Protozoa, Porifera, and spermatozoa to which as yet no function has been ascribed.

Almost every cilium whose structure has been made out consists of an axial rod or canal filled with cell sap or protoplasm, and a sheath consisting of cuticle or protoplasm. In the velar cilium described above, we have no doubt that the elastic rod is surrounded by a protoplasmic or cuticular sheath.

The large swimming plates of ctenophores, which are formed by the fusion of a number of cilia, have been carefully studied by Verworn.[1] In the position of rest, the plate is parallel to the sur-

[1] Verworn, M. Studien zur Physiologie der Flimmerbewegung. *Arch. f. d. g. Physiol.*, 1891, 48, p. 149–180.

face of the body and points toward the aboral pole of the animal. Its base is sharply bent toward the aboral pole and its distal portion is concave outward. The contraction of the oral side of the base of the plate first straightens out the basal curve and then bends the base of the cilium over toward the mouth. While the contraction of the base is taking place the distal portion of the plate is first flattened by the resistance of the water and then is bent into a curve of shorter radius by the contraction of its oral side. At the end of the stroke, the cilium is again parallel to the surface

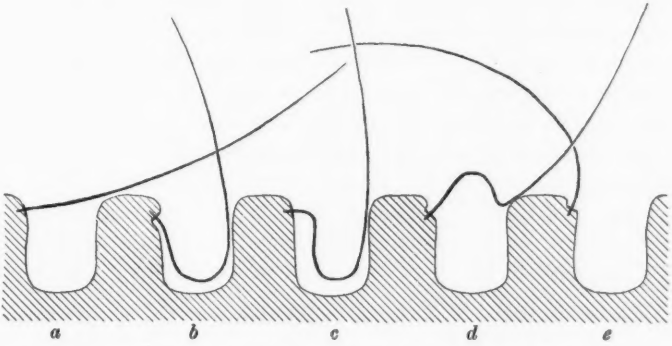


FIG. 1.— Diagram showing successive stages in the stroke of a cilium in the velum of a gastropod larva.

of the animal but it points toward the mouth and its single concavity is directed inward. Smooth muscle fibers pass from the gastric canal, which underlies each row of cilia, to the rib which carries the swimming plates; by their contraction they draw the rib into the gelatinous tissue of the body. Verworn believes that the sole function of these muscle cells is to draw the plates from the surface for the protection of the plates, and also that the movement of the cilium is caused chiefly by the contraction of its base. He does not suggest the existence of an axial supporting rod. It is possible, however, that the muscles underlying the plates may assist in the movements of the cilium and that it is really quite similar functionally to the velar cilia.

The tails or flagella of spermatozoa undoubtedly consist of an

axial rod with a protoplasmic sheath which often bears undulatory membranes. The tails of the vast majority of spermatozoa seem to lack the power of movement when separated from the basal body and cell protoplasm, and we believe that this indicates a dependence of the cilium upon a muscle-like structure around the basal body. In Salamandra, as reported by Meves,[1] and in many protozoa a

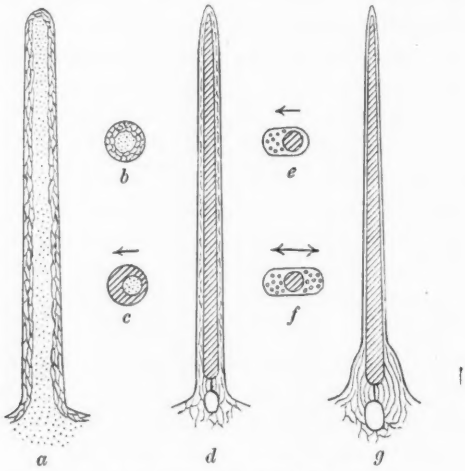


FIG. 2.— Diagram showing the hypothetical structure cilia.
a, primitive cilium with fluid core and contractile sheath.
b, cross section of *a*.
c cross section of a cilium according to Schäfer's theory of ciliary structure.
d, more highly developed cilium with basal body and elastic axial rod.
e, cross section of an irreversible cilium.
f, cross section of a reversible cilium.
g, cilium in which the contractile portion is confined to its base.

flagellum or cilium separated from the basal body and the cell protoplasm is capable of motion. In these cases doubtless the contractile substance is not confined to the base of the flagellum but extends into, perhaps throughout, the sheath (Fig. 2, *d*). The vast majority of cilia and flagella, however, can move only while in connection with protoplasm and the basal body. A different interpretation has been given to these facts by Pütter[2] and

[1] Meves, F. Über Structur und Histogenese der Samenfäden des Meerschweinchen. *Arch. f. mikr. Anat.*, 1899, 54, p. 329–402, vide p. 382.

[2] Pütter, A. Die Flimmerbewegung. *Erg. Physiol.*, 1902, 2, Abth. 2, p. 1–102.

others who consider that the isolated cilium is capable of motion but lacks only the necessary stimulus.

That the core or axis of the cilium is always solid is rendered improbable by the fact that many pseudopodia and the tentacles of the Suctoria, which are admittedly homologous with cilia, clearly have a central canal or a fluid core (Fig. 2, *a*). Moreover the experiments of Zacharias [1] who caused the spermatozoa of Polyphemus to produce slender cilia-like pseudopodia by immersing them in a 5 per cent. solution of sodium phosphate, and of Prowazek [2] who saw the retracting protoplasm of an injured cell thread of *Siphonaea bryopsis* produce in five minutes cilia which beat at the rate of 40 strokes a minute, and who [3] also found in Chilomonas cilia appearing as small processes which in 8 minutes attained half their normal size and beat 19 times in 20 seconds, show that certain cilia must consist of but slightly modified protoplasm. These experiments also indicate that a solid or a permanent core is not always formed, for in the first two cases the cilia were quickly destroyed. It is clear that a tube containing a fluid which cannot escape either because of the cell turgor or because enclosed in the tube, will act precisely as an elastic solid. In this connection Gurwitsch's [4] discovery that a marked increase in cell turgor accompanies the formation of cilia, and the cases of contraction of the cell or movements of the nucleus indicating such contraction, synchronously with the stroke of the cilia of the cell, all suggest that the turgor holds in, or the contraction of the cell forces into, the cilium the fluid which forms its support. This consideration in turn suggests a function for the ciliary roots which may increase the turgor of the cell by drawing its walls together.

These various considerations have been utilized in the current theories of ciliary action and structure, especially in the most generally accepted theory which is supported with various modi-

[1] Zacharias, O. Über die Amöboiden Bewegungen der Spermatozoen von Polyphemus pediculus. *Zeit. f. wiss. Zool.*, 1885, 41, p. 252–258.

[2] Prowazek. Protozoenstudien II. *Arb. a. d. Zool. Inst. Univ. Wien*, 1900, 12, p. 243–300.

[3] Prowazek. Protistenstudien III. *Arb. a. d. Zool. Inst. Univ. Wien*, 1902, 14, p. 81–88.

[4] Gurwitsch, A. Studien uber Flimmerzellen. I. Histogenese der Flimmerzeller. *Arch. f. mikr. Anat.*, 1901, 57, p. 184–229.

fications by Engelmann,[1] Pütter, Parker[2] and Gurwitsch.[3] According to this theory, the cilium consists of an axial support and a contractile protoplasmic sheath. The nature of the axis has been less the subject of discussion than that of the sheath which Engelmann regards as fibrillar, Pütter as protoplasm with temporary fibrillar arrangements, and Gurwitsch as protoplasm of changing surface tension. As stated above, Verworn thinks that the cilium of ctenophores is formed of two columns of contractile protoplasm whose differential contraction moves the cilium, and Engelmann seems to lean toward this view.

Less generally accepted theories are those of Benda and Schäfer. Benda[4] believes that the cilium is passive and is operated by a mechanism at its base, but the cases cited above of the movement of cilia entirely separated from the basal body and the cytoplasm, and the failure with few exceptions to find such a mechanism, make this view unacceptable. The velar cilia above described, the existence in some cells of the hypobasal layer which seems to consist of contractile protoplasm, and the partial agreement of Verworn's observations upon ctenophore cilia suggest, however, that although this theory will not apply to all cilia, it is the only theory which explains the action and structure of certain cilia.

Schäfer[5] regards the cilium as an elastic tube (Fig. 2, *c*), one side of which is less elastic than the rest, into which fluid flows or is forced causing the cilium to bend over toward its less elastic side.

This theory is plausible and the structure is mechanically possible but it fails to explain some points, as, for example, the reversal of ciliary action and the presence of axial rods in spermatozoan flagella. It seems, however, that the action of the suctorian tentacles which are evaginated and invaginated like the finger of a glove can only be explained by this theory.

[1] Engelmann, T. W. Cils Vibratils, in Richet's *Dictionaire de Physiologie*, Tome 3, 1898, p. 785–799. See also older works by the same author.

[2] Parker, G. H. The Reversal of Ciliary Movement in Metazoans. *Am. Journ. Physiol.*, 1905, 13, p. 1–16.

[3] Gurwitsch, A. Morphologie und Biologie der Zelle. Jena, 1904, vide p. 76 ff.

[4] Benda, C. Über neuer Darstellungsmethoden der Centralkörperchen. 1901, *Arch. f. Anat. und Physiol., Physiol. abth.*, 1901, p. 147–157.

[5] Schäfer, E. A. Theories of ciliary movement. *Anat. Anz.*, 1904, 24, p. 497–511. See also *Anat. Anz.*, 1905, 26, 517–521, and *Proc. Royal Soc. London*, 1891, 41, 193–198.

The generally accepted theory is undoubtedly correct but it can now be stated more fully than heretofore and can be, in a measure, harmonized with the less acceptable theories. All protoplasmic processes, cilia, flagella, pseudopodia, and suctorian tentacles, are of essentially the same structure and consist of a contractile protoplasmic sheath which encloses a solid or fluid supporting core. Primitively the sheath (Fig. 2, *a*) is contractile throughout and is not marked off structurally or functionally from the remainder of the ectoplasm. Secondarily the sheath becomes differentiated into contractile and noncontractile portions, the relations of which are shown in the following examples. The contractile protoplasm (Fig. 2, *g*) of velar cilia and ctenophore plates is practically confined to the base of the cilium. Parker has shown that in reversible cilia (Fig. 2, *f*) the contractile substance must occur in two opposite bands which in Metridium are on the oral and aboral sides of the supporting axis. Ordinarily the aboral band contracts more strongly than the other and drives water away from the mouth but certain organic and inorganic substances cause the oral band to contract more strongly and so to reverse the direction of the effective stroke and of the currents caused by it. Parker shows also that irreversible cilia (Fig. 2, *e*) probably have but one band of contractile material. Ballowitz[1] has shown that spermatozoan flagella have a fibrillar axial structure surrounded by a sheath of uneven thickness and Pütter with others have shown that the axial rod supports the irregular contractile protoplasmic sheath.

The core of the pseudopodium, which is to be regarded as the simplest cilium, is fluid. In higher stages of ciliary development a solid, which is elastic in cilia and flagella and inelastic in pendulous pseudopodia, replaces the fluid core.

HARVARD MEDICAL SCHOOL
Boston, Mass.

[1] Ballowitz, B. Untersuchungen über die Structur der Spermatozoen, zugleich ein Beitrag zur Lehre vom feineren Bau der kontractilen Elemente. *Arch. f. mikr. Anat.*, 1888, 32, p. 401–473.

THE POISON GLANDS OF NOTURUS AND SCHILBEODES

HUGH DANIEL REED

THE eleven species of Noturus and Schilbeodes are popularly known as "stone cats" and "mad toms." They are small catfishes found in the lesser streams from New York and New Jersey west to Wyoming and Montana, and south to Georgia, Alabama and Texas, being most abundant in the Great Lake, Ohio and Upper Mississippi regions. They may be distinguished from other catfishes by the presence of a *keel-like* adipose fin joined to the back and more or less continuous with the caudal fin. The two genera, which appear very much alike, may be distinguished from each other by means of the pad of villiform teeth on the upper jaw. In Noturus this pad of teeth, at each outer caudal angle, possesses a backward extension which is absent in Schilbeodes.

It has long been known that the mad toms can inflict a painful wound with their pectoral spines. The sensations produced by the wounds, and the presence of a pore in the axilla, have led to much speculation respecting the presence of a poison-secreting gland which anoints the spine. Some take it for granted that such an organ exists, others are doubtful, and recently the presence of poison glands in these fishes has been denied altogether.

Günther ('80 b) recognized the existence of a sac in the axilla of certain catfishes and says,— "It does not seem improbable that it contains a fluid which may be introduced into a wound by means of the pectoral spine.... However, whether this secretion is equally poisonous in all the species provided with that axillary sac, or whether it has poisonous qualities at all, is a question which can be decided by experiments only made with the living fishes."

Jordan and Gilbert ('82) under the description of the genus Noturus[1] say,— "In or above the axil of the pectoral fins is an orifice, which is the opening of the duct of a poison gland." To

[1] What now constitute the genera Noturus and Schilbeodes were then included under the generic term Noturus.

this is added a quotation from Cope,— "From it [the pore] may frequently be drawn a solid gelatinous style ending in a tripod, each limb of which is dichotomously divided into short branches of regular length." Jordan and Evermann ('96) make a similar statement and add,— "The sting from the pectoral spine is very painful, resembling the sting of a bee, but worse." Again, Jordan ('04) writes the following footnote,— "The wounds produced by the sting of their sharp pectoral spines are excessively painful. In the axil is usually a pore, probably the opening of a duct from a poison gland. This matter deserves investigation." Finally ('05) he writes,— "In two genera, Noturus and Schilbeodes, a poison gland exists at the base of the pectoral spine, and the wound gives a sharp pain like the sting of a hornet and almost exactly like the sting of a scorpion-fish."

Boulenger ('04) does not consider this axillary sac a poison gland. In this connection he says,— "I think this condition of things has nothing to do with a poison organ, and is merely a repetition of what is observed in loaches and in the characinid Xenocharax, where I have found a gelatinous substance filling the short duct by which the membrane of the air bladder is placed in communication with the skin and the sensory organ of the lateral line."

Poison organs in connection with various spines have been found in several different groups of fishes. Günther ('69) has described a poison apparatus in *Thalassophryne reticulata* which inflicts a wound followed by poisonous symptoms. At the base of the dorsal and opercular spines in this species he found a sac connected with a canal passing through the whole length of the spine and opening through a slit at its distal extremity. Thus the spine resembles the fang of a poisonous snake. Günther concluded by saying, "Nobody will suppose that a complicated apparatus like the one described can be intended for conveying an innocuous substance and therefore I have not hesitated to designate it as poisonous; and Capt. Dow informs me in a letter lately received, that 'the natives of Panama seemed quite familiar with the existence of the spines and of the emission from them of a poison which, when introduced into a wound, caused fever, an effect somewhat similar to that produced by the sting of a scorpion;

but in no case was a wound caused by one of them known to result seriously. The slightest pressure of the finger at the base of the spine caused the poison to jet a foot or more from the opening of the spine'."

The weever fishes (Trachinus) found along the coast of Europe inflict very severe wounds with their dorsal and opercular spines. This was so well known that in some towns, at one time, there were regulations providing for the removal of the spines before the fishes were displayed in the markets. Schmidt ('75) and Parker ('88) independently found well developed glands about the dorsal and opercular spines. There are numerous references to the poisonous nature of the weever fishes, but the two authors mentioned are the only ones, so far as I know, who have described the structure of the glands.

Wallace ('93) in the toadfish, *Opsanus* (*Batrachus*) *tau*, discovered glands in connection with pores in the axilla, on the dorsal portion of the operculum and on the surface of the pectoral fin. This author does not consider them as poison glands although the spines of this species give a "slightly painful sting" and the glands apparently are of the same type as those of the weever fishes described by Schmidt and Parker, and those of the mad toms to be described presently.

With the above facts and views in mind and a desire to know more of the action and structure of the supposed poison glands, all the known species[1] of Noturus and Schilbeodes, except *S. funebris*, have been examined. The sting will be described first, and then the structure of the glands.

The Sting.— The sting of the mad toms has been described as like that of a bee. In *Schilbeodes gyrinus* the sensations produced do not differ materially from those of a bee but as a rule the pain is not so intense and is usually confined to the wounded region. Frequently a very severe sting upon the end of the finger caused pain throughout the hand and wrist. In several cases after receiving deep punctures on the end of the finger, sharp pains which continued for several hours, were experienced to the elbow. Dr.

[1] The author wishes to acknowledge his indebtedness to Dr. C. H. Eigenmann, Dr. B. W. Evermann and the authorities of the National Museum for the generous loan of specimens for study.

Evermann (MS.) describes the pain as, "A very stinging sensation, more like that which would result from a severe nettle sting.' This describes precisely the majority of stings, for in handling live specimens ordinarily only the tip of the spine enters the flesh. The mechanical injury is so slight that it frequently is impossible to locate the wound except for the stinging sensation. From an ordinary sting, such as is received in handling the live fishes, the pain continues from one to several hours, depending probably upon the amount of poison entering the wound. Both in sensation and duration these wounds differ from those made by the prick or puncture of a sharply pointed instrument. The swelling is hardly perceptible,[1] except in cases of very severe punctures, in which event the flesh about the wound becomes distinctly swollen

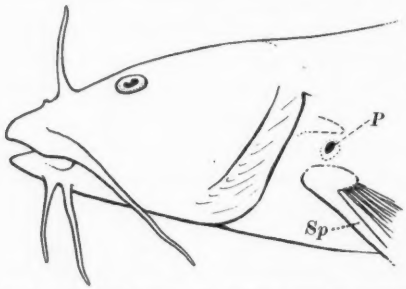


FIG. 1.— The head of *Noturus flavus*. *P*, axillary pore or opening of axillary gland. Sp, pectoral spine.

and slightly discolored. Similar results, but more marked, are produced by introducing a portion of a fresh gland underneath the skin.

The Poison Glands.— All the species of Noturus and Schilbeodes possess axillary glands which open through a pore situated in the axilla just below the post humeral process (Fig. 1, *P*). The position of the pore with reference to the base of the fin and the humeral process varies somewhat in different species. In all, the pore is more or less slit-like and is situated so that when the fin is adducted the spine lies either directly across or parallel with it. Thus the transfer of secretions to the spine may be accom-

[1] *Schilbeodes gyrinus* was the only species available for experimentation. Some other species of the genus are said to be more virulent.

plished during adduction but it is doubtful if this is the usual method of anointing the spines. In most of the species the pore is opened widely when the fin is abducted. In *Schilbeodes insignis* the lips of the pore, if anything, are drawn closer together by the abduction of the fin. In approaching each other, however, the lips of the pore are continued to the base of the spine as two slight folds with a groove between them. Thus the secretions would find a safe conduit from the pore to the spine.

The glands are pear-shaped, with the apex toward the axillary pore (Fig. 2, p. g. and p. o.). In most species examined, the gland is inclined backwards and lies just beneath the skin and entad of the posthumeral process (Fig. 2, h). It is surrounded by loose connective and adipose tissue. In *S. gyrinus* the gland extends farther towards the head than in some other species. In all species the gland, though small, is macroscopic. In a specimen of *Noturus flavus* 17 cm. long the greatest diameter of the gland was 5 mm.

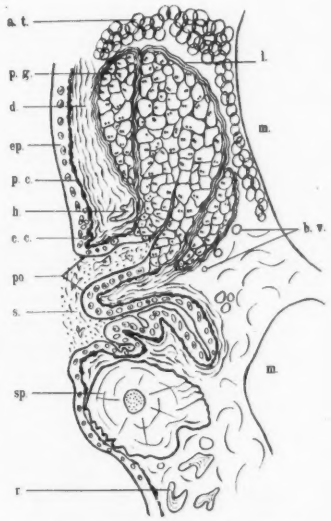


FIG. 2.— Section through the axillary gland and pectoral spine of *Schilbeodes miurus*. *a. t.*, adipose tissue. *p. g.*, axillary poison gland. *d.*, corium. *ep.*, epidermis. *p. c.*, layer of pigment cells. *h.*, post-humeral process. *c. c.*, clavate cells of the epidermis. *po.*, axillary pore. *s.*, secretion. *sp.*, pectoral spine. *r.*, fin-ray. *l.*, sheath of the gland. *m.*, muscle. *b. v.*, blood vessels.

The glands are divided into three main lobes, each of which is subdivided into lobules. The lumen of the gland is extremely narrow except near the pore where it is comparatively wide. It can be traced in sections however, through the main lobes and for a short distance into the subdivisions. The tripod style which Cope withdrew from the pore was probably the hardened secretion of the gland, each of the three legs of the style corresponding to the lumen of the three main divisions of the duct and the dichotomous branches repre-

senting the lumens of further subdivisions. I have frequently found globular masses of the secretion filling and depending from the pore (Fig. 2, s) but have been unable to withdraw one with the branches intact. The secreting cells are granular and very large. They range between 80 and 200 microns in their greatest diameter, and vary in shape due to compression with neighboring cells. Most of the cells contain two large nuclei. As a rule the two nuclei are separated by a short space, but frequently they are found very close together or apparently joined. This may indicate recent division as Parker has suggested in con-

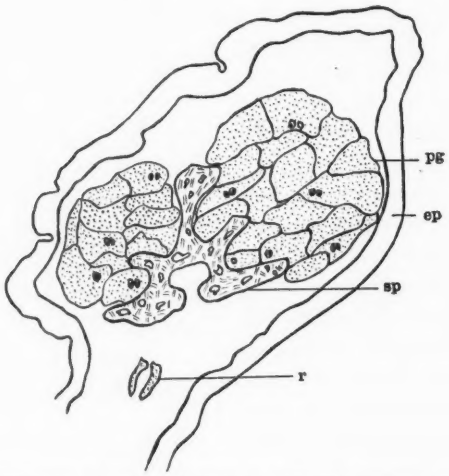


FIG. 3.— Transection of the dorsal spine of *Schilbeodes gyrinus*. *pg*, poison gland. *ep*, epidermis. *sp*, dorsal spine. *r*, fin-ray.

nection with similar phenomena in the poison glands of the weever fishes. Further evidence of division has not been apparent.

The entire gland is surrounded by a sheath which reaches the bottom of the fissures between the primary and secondary lobes. (Fig. 2, l). Every secreting cell is lodged in a loose network of elongated spindle-shaped cells which Schmidt has named supporting cells. Each has a nucleus in its central part. The gland is richly supplied with blood vessels which are lodged in its sheath and between its lobes.

Besides the axillary glands, two species, *Schilbeodes gyrinus* and *S. nocturnus*, each possess glands beneath the skin which covers the dorsal and pectoral spines. Both spines are situated in front of and are shorter than the first soft rays of their respective fins. Both are grooved, as shown in the transection Fig. 3, sp. Near the base of the spines the grooves are more complex. If an uninjured specimen be examined, at the middle of the extent of these spines there will be noticed a swelling which tapers towards either end. The gland (Fig. 4, pg) is coextensive with this swelling and occupies nearly all of the space between the skin and the spine which it surrounds (Fig. 3, pg). At the end of the spine there is a slit in the epidermis through which the spine projects slightly. In preserved specimens it is not unusual to find a globular mass or a long filament of the hardened secretion attached to the end of these spines. The sting of the dorsal spine in *Schilbeodes gyrinus* is precisely like that of the pectoral. The

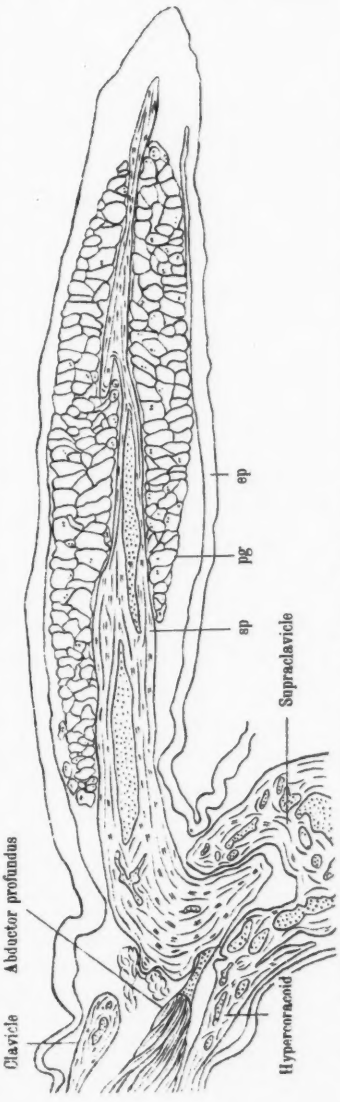


FIG. 4.— Longitudinal section of the pectoral spine of *Schilbeodes gyrinus*. *sp*, pectoral spine. *pg*, poison gland. *ep*, epidermis.

same will probably be found true of *S. nocturnus* for the dorsal spine gland is here as well developed as the pectoral. The presence of spine glands may be determined by carefully slitting the overlying skin and scraping the spine with a needle. If the gland is present, the scrapings when stained and mounted show the typical gland structure almost as clearly as sections. Sometimes the structure can be made out with a dissecting lens without either staining or scraping the tissue from the spine. In the fresh condition the glands are of a translucent jelly-like consistency and appearance. There is no difference in structure between the axillary and spine glands.

It appears from the figures and descriptions of Schmidt and Parker that the poison organs of the mad toms and the weever fishes are identical in structure. In the latter group the glands are found only in connection with the opercular and dorsal spines which they surround in precisely the same manner as do the pectoral and dorsal glands of *Schilbeodes gyrinus* and *S. nocturnus*.

Differential stains fail to reveal the presence of any muscular fibers which might by their contraction exert pressure upon the cells and force their secretions to the exterior. The same is true according to Schmidt and Parker of the weever fishes. The latter ('88) writes,— "No special muscles are present in connection with the glands.... I am inclined to think that in the discharge of their secretions the cells simply burst." Schmidt ('75) observes that "Along the ventral side of the upper gland are found a few bundles of the extensor muscle of the gill cover but they could hardly produce any pressure on the gland, and moreover, no organ, adapted for active ejection of the secretion, is found." It appears that the cells are destroyed when the secretions are released, for in no case has a natural opening been found in the cells, and the secretions when stained are found to contain ruptured and ragged cells in many of which the nucleus can still be made out. Frequently uninjured cells are found floating in the secretions along with the ruptured ones. Usually these are small cells, probably immature ones, which have been torn away with the others.

The relation of the fin and body muscles to the gland is such that no amount of contraction can produce any pressure upon it.

It is improbable that the glands depend upon the application of external pressure, such as would result if the fish were seized in the axillary region by another animal. It is doubtful whether, in those species which possess spine glands, the spines are ever inserted far enough into the flesh of the victim to produce pressure as a result of the slipping of the skin away from the tip and towards the base of the spine. Such was Byerley's ('49) explanation of the ejection of the poison from the glands of the weever fishes but it was not accepted later by Schmidt and Parker. Judging from the size of the wound inflicted by these forms which possess spine glands, the exposed portion of the spine is probably as much as is usually inserted into the flesh. It seems probable that the cells of both axillary and spine glands are ruptured from the outward pressure exerted by their own contents. The ruptured cells are not found in one place but are scattered through the gland, and the secretion may be seen streaming through the lumen and pore, out along the folds of skin on the dorsal surface of the spine toward its tip. In specimens which have been carefully handled a globule will be found depending from the axillary pore or a stream of the secretion extending from it to the pectoral spine. The end of the pectoral and dorsal spines in *Schilbeodes gyrinus* is usually found with a globule or wavy filament of the poison. Thus always supplied with poison at its very tip it can be readily understood how the slightest prick produces results.

It is worthy of note that spine glands are found only in those species where serrae upon the spines are absent or very few and weak. A serrate dorsal spine without a gland apparently cannot inflict a stinging wound, but the non-glandular serrate pectoral spines are supplied with poison from the axillary glands. Although no difference in the relative size or specialization of the axillary glands in the two groups has been noted, the species with serrae are considered more poisonous than those without. The presence of serrae makes possible the infliction of a large number of wounds and consequently the introduction of a large amount of poison at one and the same time. This would render such species more formidable although the poison is secreted in smaller quantities and is no more virulent. Certainly spines without serrae can inflict wounds from the tip end only and being some distance from

the axillary pore would most likely be poorly provided with poison except for the presence of a gland opening at the very end. It seems plausible, therefore, that the absence of serrae is correlated with the presence of glands developed about the spines, as in *Schilbeodes gyrinus* and *S. nocturnus* and as probably will be found in *S. leptacanthus* [1] when an uninjured individual is examined.

The Origin of the Gland Cells.— Cutaneous glands are generally to be regarded as invaginations or proliferations of the epidermis, certain cells of which become transformed into the secreting cells. Wallace ('93) has shown that in the axillary glands of the toadfish the clavate cells of the epidermis become the secreting cells, whereas

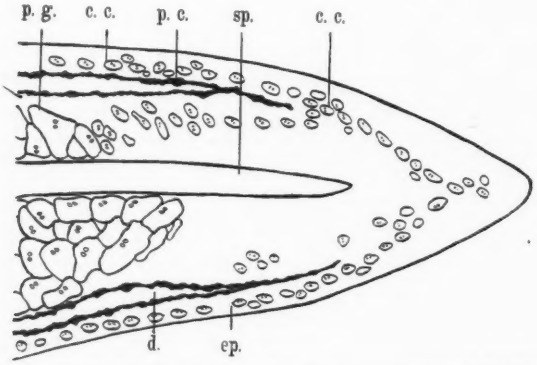


FIG. 5.— Longitudinal section of the end of the pectoral spine of *Schilbeodes gyrinus*. *p. g.*, poison gland. *c. c.*, clavate cells. *p. c.*, layer of pigment cells. *sp.*, pectoral spine. *d.*, corium. *ep.*, epidermis.

the smaller cells become the supporting elements. Similarly, in writing of the weever fishes, Schmidt says,— "After a comparison of the contents of the gland sac and the adjacent epidermis it seems clear that in the gland tissue the secreting cells replace the clavate cells and that the ordinary epidermal cells are gradually transformed into the supporting plexus." Parker calls attention to the lack of well defined ducts in the glands of the weever fish. He says,— "There can be little doubt that the gland is developed as an epidermic involution the whole of which gives rise to secre-

[1] The only specimen available was a very small one, the spines of which had been denuded of all tissue whatsoever.

tory cells, so that there is no marked differentiation into gland and duct."

The glands in Noturus and Schilbeodes are likewise invaginations of the epidermis. They are surrounded by a sheath of corium pushed inward by the developing gland. As shown in Fig. 2, *d* and *l*, the sheath is thinner and denser than the rest of the corium, with which it is continuous around the neck of the gland. Between the corium and epidermis in most regions of the body there is a layer of pigment cells (Fig. 2, p. c.) which is frequently found to extend about the gland between the sheath and the gland tissue, thus occupying the same relative position as in the skin. The arrangement of the pigment layer in relation to the spine glands shows that they are invaginated from near the tip of the spine. Near the tip, the pigment layer (Fig. 5, p. c.) turns upon itself and passes over the gland to its base, toward the root of the spine. Thus the gland is invested by two layers of pigment cells with corium between them (Fig. 5, d). The clavate cells of the skin and the secreting cells of the gland form an uninterrupted series (Fig. 5, c. c. and p. g.), the former gradually increasing in size so that in sections it is sometimes impossible to draw the line between the two. The other cells of the epidermis as the gland is approached, gradually assume an irregular shape, then becoming more elongated they are finally transformed into the extremely slender cells which constitute the supporting tissue.

The invagination is much more extensive and the specialization of elements proceeds much further in the mad toms than in the toadfish. In the glands of the latter the epidermal character of the cells is barely lost. Thus the slime cells, which in the mad toms are apparent only in the skin, according to Wallace's figures are perfectly distinct in the glands of the toadfish, and project into the gland cavity.

Summary

1. All of the species of Noturus and Schilbeodes, except *S. funebris*, have been examined; they are found to possess an axillary pore which is the opening of a gland.

2. Experiments with *Schilbeodes gyrinus* indicate that the secretions of the glands are poisonous.

3. In addition to the axillary glands *Schilbeodes gyrinus* and *S. nocturnus* possess glands developed about the pectoral and dorsal spines. These are of the same type and structure as the axillary glands. The end of such a gland-bearing spine projects slightly through a slit in the epidermis.

4. Spine glands are not found in those species which possess well developed serrae upon the spines.

5. *Schilbeodes leptacanthus*, because of its close relation to *S. gyrinus*, would be expected to possess spine glands in addition to the axillary glands.

6. A study of the mature glands tends to justify the following conclusions:

a. The glands are of epidermal origin; those in the axilla invaginate from the pore, and those in the spines from the slits near the tips of the spines.

b. The gland sheath is modified corium.

c. The clavate cells of the skin become the secreting cells of the gland.

d. The ordinary epidermal cells become elongated, forming the supporting network of the secreting cells.

e. The glands of the mad toms are essentially like those of the weever fishes.

f. The glands of the toadfish, although of the same type, are intermediate in structure between the glands of the mad toms and unmodified epidermis.

g. There are no muscles for rupturing the cells and forcing out the secretion. The cell walls are evidently ruptured by the pressure of their contents. In this way the spines are constantly anointed with the poisonous secretion as may be seen by examining uninjured specimens.

CORNELL UNIVERSITY
ITHACA, N. Y.

LITERATURE.

ALLMAN, G. J.

'41. On the Stinging Property of the Lesser Weever. (Trachinus). *Ann. Nat. Hist.* 1841, vol. 6, p. 161.

BOULENGER, G. A.

'04. The Cambridge Natural History, *Fishes, Ascidians, etc.*, 1904, vol. 7, p. 590. Macmillan Co., N. Y.

BRIDGE, T. W.

'04. The Cambridge Natural History, *Fishes, Ascidians, etc.*, 1904, vol. 7, p. 177. Macmillan Co., N. Y.

BYERLEY.

'49. Poison of Weever Fishes. *Proc. Literary and Philosophical Soc.*, Liverpool, 1849, p. 156.

CHIEVITZ, J. H.

'88. Notice on Professor W. Newton Parker's Communication, "On the Poison Organs of Trachinus." *Anat. Anz.*, 1888, p. 787.

CUVIER. [Remarks upon the poison of the weever fishes]. *Hist. Nat. des Poissons.* T. 3, p. 184.

DAY. [Remarks upon the poison of the weever fishes].

'80–'84. *The Fishes of Great Britain and Ireland*, vol. 1, pp. 78–82. London.

GESSIN, LEON.

'84. Contributions à l'étude de l'appareil a venin chez les poissons du genre "vive" (Trachinus). *Thèse de Paris.* 1884.

GÜNTHER, A.

'64 On a Poison Organ in a genus of Batrachoid Fishes. *Proc. Zool. Soc. Lon.*, 1864, p. 157.

'69. An account of the Fishes of the States of Central America Based on Collections made by Capt. J. M. Dowe, F. Go lman Esq., and O. Salvin Esq., *Trans. Zool. Soc. Lon.*, 1869, vol. 6, p. 439.

'80 a. Article on "Ichthyology" in *Ency. Brit.*, 1880, vol. 12, p. 190.

'80 b. An Introduction to the Study of Fishes. Edin., 1880. p. 192.

JARDIN, SIR WM.

'43. British Fishes, pt. 1. *Naturalists Library*, 1843, vol. 4 (Ichthyology), pp. 135–137.

JORDAN, D. S.

'04. Manual of Vertebrates. 1904, p. 41, McClurg & Co., Chicago.

'05. A Guide to the Study of Fishes. 1905, vol. 2, p. 177. Henry Holt & Co., N. Y.

JORDAN, D. S. AND GILBERT, C. H.

'82. Synopsis of the Fishes of North America. *U. S. Nat. Mus.*, 1882, bull. 16, p. 98.

JORDAN, D. S. AND EVERMANN, B. W.
'96. The Fishes of North and Middle America. *U. S. Nat. Mus.*, 1896, bull. 47, p. 145.

KENT, W. SAVILLE.
'83. British Marine & Fresh Water Fishes. *Fisheries Exhibition Handbook*, 1883, p. 29. London.

PARKER, W. N.
'88. On the Poison Organs of Trachinus, *Proc. Zool. Soc. London*, 1888, p. 359.

SACCHI, MARIE.
'95. *Atti. Soc. Ligust.*, 1895, vol. 6, p. 89.

SCHMIDT, F. T.
'75. Om Fjarsingens Stik og Giftredskaber. *Nord. Med. Arkiv.*, 1875, vol. 6, nv. 2.

TYBRING, OSCAR.
'86. Poisonous Fishes. (Translated from the Danish by Hermann Jacobson). *Bull. U. S. F. C.*, 1886, vol. 6, p. 148.

WALLACE, LOUISE B.
'93. The Structure and Development of the Axillary Glands of Batrachus. *Journ. Morph.*, 1893, vol. 8, p. 563, pl. 27.

WIEDERSHEIM, R.
'06. Vergleichende Anatomie der Wirbelthiere. 1906, Jena.

WRIGHT, R. R.
'84. *Proc. Can. Inst.*, 1884, vol. 2, p. 252.

THE STRUCTURE OF THE SILK GLANDS OF *APANTELES GLOMERATUS* L.[1]

ROBERT MATHESON AND A. G. RUGGLES.

Apanteles glomeratus is a hymenopterous social parasite of the larvae of *Pieris rapae*, the common cabbage worm. The adult females deposit at each oviposition from fifteen to thirty-five eggs in the young larvae of Pieris. The parasites on hatching, feed upon the lymph and fatty tissue of their host and grow very rapidly, becoming full grown at about the end of the larval life of the caterpillar. They then penetrate through the skin of their host and, while emerging, spin their characteristic sulphur-yellow cocoons. The silk glands, as seen in sections of the mature larvae, are enormously developed. Although the silk glands of lepidopterous and trichopterous larvae have been the objects of detailed study by Helm, Gilson, and others, very little is known concerning these glands in the Hymenoptera. As regards histological structure the only works of importance are those of Cholodkovsky, his student Pikel, and Bordas; and, excepting the latter who gives a brief discussion of these glands in the aculeate Hymenoptera, these writers have confined themselves to the study of the larvae of various Tenthredinidae. Therefore at the suggestion of Professor Riley we were led to investigate more fully the silk glands of Apanteles.

The work was carried on in the Entomological Laboratory of Cornell University. We wish to extend our thanks to Professors Comstock, Riley and MacGillivray, for their constant aid and advice.

Anatomical Disposition of the Silk Glands.— The silk glands of *Apanteles glomeratus* arise near the base of the labium and extend through the body cavity to the antepenultimate segment of the abdomen. In the abdominal region of mature larvae they consist of two pairs of thin-walled, much convoluted, cylindrical tubes (Pl. 1, fig. 3) which completely surround the alimentary

[1] Contributions from the Entomological Laboratory of Cornell University.

canal. Each pair of tubes unites in the first abdominal segment to form a common thoracic division. These common tubes, extending forwards with many convolutions in the thorax, turn ventrad just behind the developing head and passing on each side of the sub-oesophageal ganglion, end in short ducts. These ducts unite in the labial region to form the press which occupies more than half of the common duct.

In young larvae just hatched, and for several days later, the glands show no convolutions whatever. They lie as straight tubes, two on each side of the alimentary canal and extend caudad to the antepenultimate segment (Pl. 1, fig. 1). Moreover the structure is the same throughout their entire length, no regional differences occurring. Their walls are thick and their lumina very small. Later they become much convoluted, and their lumina are greatly distended, till in the mature larvae at time of emergence from the host, the abdominal division has practically ceased to secrete, becoming simply a reservoir for the already accumulated product.

The silk glands may be divided into two general divisions; 1. Secretory. 2. Conducting.

The Secretory Division.— The secreting division may be conveniently divided into two portions, abdominal and thoracic.

The abdominal portion comprises that part of the gland extending caudad from the point of juncture of the glandular tubes in the first abdominal segment.

In the freshly hatched and young larvae this portion consists of two pairs of straight glandular tubes, one pair situated on each side of the alimentary canal (Pl. 1, fig. 1). On each side the tubes lie directly one above the other. No difference in structure between the dorsal and ventral tubes could be detected. In cross section the gland is seen to be composed of two large cells surrounding a very small lumen (Pl. 1, fig. 9). Each cell is almost completely filled by a large unbranched nucleus. Externally lies the basement membrane (*b. m.*), a delicate structureless sheath surrounding the gland. On the inner surface lies a delicate, thin membrane, the structure of which we were unable to make out under the highest powers of the microscope. It appears as a thin, resistent, structureless membrane. Gilson, '90, has worked out in detail its struc-

ture in the larvae of *Bombyx mori*. He concludes his study by stating that the producing portion is clothed by an extremely fine resistent cuticula, in which are found spiral filaments of various thicknesses, united to one another by delicate transverse or oblique trabeculae. He does not consider that these meshes are closed by a structureless lamella but refrains from a positive statement.

As the larvae feed and grow, this portion, during the third and fourth days, commences to become convoluted; the nuclei are larger and somewhat branched; the lumen slightly increases in size. Gradually, as the cells begin to secrete actively, the glandular tubes become more and more convoluted until, at the time of emergence of the parasite from the host, they almost completely fill and greatly distend the perivisceral cavity. These changes are brought out in the longitudinal sections of young and mature larvae respectively, Pl. 1, figs. 2 and 4, and in corresponding cross sections, Pl. 2, figs. 7 and 8.

Along with the great increase in length of the glandular tubes goes a corresponding increase in size. The cells necessarily become larger, but their radial diameter diminishes. The lumen gradually becomes distended by the accumulated product, till, at the time of the spinning of the cocoon, the walls are reduced to a very thin layer (Pl. 1, fig. 11). The figures 9, 10, and 11 show the enormous increase in the size of the lumen during the very short larval life. So great is this increase that either cross or longitudinal sections of an adult larva present a very striking appearance, practically the whole body cavity being monopolized by the silk gland.

The nuclei in the glands of the young larvae are round or oval in shape and fill the greater part of the cells (Pl. 1, fig. 9). As these cells commence actively secreting the nuclei become more and more branched. The shape of the nuclei at nearly four days is shown in Pl. 3, fig. 31; during the latter part of the larval life they appear as if fragmented (Pl. 3, fig. 34). Gilson records complete fragmentation of the nuclei in certain cells of the larger part of the glandular tubes in Bombyx and Trichoptera. Marshall and Vorhies, '06, could not confirm this in the case of *Platphylax designatus* and they also deny the anastomosing of the branches.

In *Apanteles glomeratus*, owing to the thinness of the glandular walls, it was impossible to secure tangential sections which would give surface views of the nuclei. As the nuclei do not stain deeply at this stage, they are rather difficult to differentiate, although we secured fairly good results by staining with Grenacher's borax carmine, as shown in figure 34.

The cytoplasm is dense, granular, and vacuolated, especially during the latter part of the larval life when the glands are at the height of their activity (Pl. 1, figs. 10 and 12). Through the cytoplasm run trabeculae, extending in many cases from the external border to the inner margin of the cell. These trabeculae appear as fine radiating lines, but later, with the thinning of the glandular walls, they disappear.

Gilson, '90, performed some interesting experiments in order to determine the method of secretion. He ligated the entire living larvae, disposing the ligatures in two pairs, the two threads of each pair being close together. He then divided the larva into three sections by cutting between each pair of ligatures. Treating the cut surfaces with mercuric chloride and collodion he secured living isolated portions of the caterpillar, in each of which the silk glands, especially near the ligatures, continued to secrete. In such isolated portions he found vacuoles present in the cytoplasm and even in the nuclei of the silk glands. These vacuoles he considered as the silk secretion. He did not succeed in establishing whether they lay between the radiating trabeculae or not. In the case of *Apanteles glomeratus* the condition which Gilson sought to obtain by mechanical means is the normal one since none of the secreted product is used till at the time of emergence from the host. Numerous vacuoles are present in the cytoplasm, becoming most abundant during the time of the greatest glandular activity. The contents of these vacuoles remain unstained by any of the coloring agents used, but the secreted product is sometimes stained as is noted later. Whether the presence of these vacuoles in the cells is due to the retention of the secreted product in the lumina of the glands remains an open question.

The thoracic portion of the secretory division of the gland consists of but two secreting tubes, lying one on each side of the alimentary canal (Pl. 1, fig. 1). Each is formed by the union of the

two tubes of the abdominal division in the first abdominal segment and extends cephalad to the short duct which begins just in front of the sub-oesophageal ganglion. The thoracic portion may be divided into three well defined parts,— the 1st, or anterior thoracic; the 2nd, or middle thoracic; and the 3rd, or posterior thoracic divisions.

The 3rd, or posterior thoracic, division during the first half of larval life consists of an almost straight cylindrical tube. Later it becomes much convoluted and its walls become thinner so that in every way it markedly resembles the abdominal portion. The cytoplasm is densely granular, deeply staining, and much vacuolated, especially near the periphery of the cells (Pl. 2, figs. 14 and 16).

The 2nd, or middle thoracic division, is quite short and straight. It extends from the beginning of the second thoracic segment to the first division. The cells of this portion of the gland have a greater radial diameter than in any other part. The layer of "gres" or "gum," so prominent in the 1st division, is very thin and in some places difficult to distinguish. The cells are characterized by a faintly staining, loosely granular cytoplasm, which near the periphery of the cells, is much vacuolated (Pl. 1, figs. 19 and 20).

The 1st, or anterior thoracic division, is also short and straight. It extends from the beginning of the first thoracic segment to the duct. This portion of the gland is characterized by a thick dense layer of "gres" or "gum" adhering closely to the inner surface of the secreting cells (Pl. 1, fig. 23; pl. 3, figs. 24 and 30). The cytoplasm of these cells is dense, granular, and deeply staining, contrasting strongly with that of the middle or 2nd thoracic division as shown in Pl. 3, fig. 24.

The nuclei of these divisions differ mainly in the extent of their branching. In the 1st they are not so markedly branched as in the 2nd, and in the 3rd, or posterior division, they are yet more ramifying. The basement membrane is of the same character as in the abdominal divisions. The internal lining of the lumen is more distinct. It appears as a thin, elastic, structureless, cuticular membrane.

A fact worthy of note is the absence of the glands of Philippi.

There is no indication of a vestige of these glands, such as Gilson found in *Limnophilus rhombicus*, one of the Trichoptera.

The Conducting Division.— The conducting portion of the silk glands is Y-shaped, with a median stem and branches pointing caudad; each branch joins the thoracic portion on its respective side of the body. The press commences at the juncture of the two branches. The entire conducting portion is very short, being wholly confined to the labium. In cross section the branches are seen to be composed of a number of cells surrounding a small lumen (Pl. 3, fig. 25). The nuclei are oval to rounded in shape,— never branched. Posteriorly the cells are columnar and contain elongated nuclei, but anteriorly the cells become flattened (Pl. 3, fig. 30). There is thus formed an enlarged lumen at the anterior end of each branch of the conducting tube. Also by the increased radial diameter of the posterior cells the amount of "gres" or "gum" that can pass forward is regulated (Pl. 3, fig. 30).

The cuticular lining of these branches forms chitinous folds or ridges which are not perfect spirals but appear as incomplete rings. (Pl. 3, figs. 25, 29 and 30, *in*).

The Press.— Although the internal disposition of the silk glands was familar to the earlier anatomists, nothing was known regarding the mechanism by which the silk thread was formed and regulated until the time of Lyonet. He designated the entire labium as the "filiere," because it was the instrument which had been given to the caterpillar for spinning. He was the first to demonstrate the presence of the press with its attached pyramidal muscles, but he did not succeed in working out its structure. He concluded by supposing that this organ acted as a pump to draw up the silk from the glandular tubes and to force it to the exterior.

Dr. Azoux, '49, in his classic model of the silk worm, represents with exactness these pyramidal muscles of the press.

Helm, '76, was the next worker who added anything new regarding this organ. His figures and descriptions of its structure are not at all exact yet he arrives at correct conclusions regarding its function. He considered it to act simply as a press in the formation of the silk thread. It was not till the important works of Gilson and Blanc that the minute structure of this organ in Lepidoptera and Trichoptera was known and its functions clearly defined.

Berlese, '06, denies the presence of a press in the silk glands of the larvae of Hymenoptera, Diptera, and Coleoptera. He figures a sagittal section of the head of the larva of *Xylotoma rosae* but does not represent muscles as present in the region of the conducting tube. On the other hand the presence of a press in hymenopterous larvae has been recorded by Eckstein, '90, in *Lyda pratensis*, and Pikel, '96, in *Lophyrus pini*. Both of these workers figure this organ as present but give no definite details regarding its structure. Pikel states that in structure it is similar to that described by Tichomirow for *Bombyx mori*.

Structure of the Press.— In the case of *Apanteles glomeratus* the press is highly developed. It commences at the union of the two conducting tubes in the region of the labium and occupies more than half of the common duct. Dorsally the press is concave, traversed by a longitudinal furrow into which pass the dorsal pair of muscles as shown in cross and longitudinal sections in Pl. 3, figs. 27, 29 and 30. The ventral surface is convex (Figs. 27 and 30); its cells are somewhat elongated and secrete the thicker chitinous layer of the common duct. The dorsal muscles consist of numerous fibers which are attached directly to the chitin along the longitudinal median furrow as shown in figures 27 and 29. Emerging from this furrow the muscles separate laterally and, passing dorsocaudad, are inserted on the chitinous layer of the floor of the buccal cavity (Fig. 27). The ventral muscles are each composed of several fibers. They are located as shown in cross section in Fig. 27. They are inserted on opposite sides of the press and, passing almost directly ventrad, have their origin on the ventral body wall, being attached directly to the chitin.

The lumen of the press, as seen in cross section (Fig. 27), is horseshoe-like in form. When the muscles are relaxed this lumen is practically closed, thus preventing the further egress of the thread. The lumen is lined with a thick chitinous layer which is more strongly developed on the ventral side. This chitinous layer is directly continuous with that of the ducts. In Fig. 27 the dorsal portion of this layer appears thick, but this is due to the obliquity of the section which was necessary in order to show the muscles in one section.

In very young larvae the press is not yet developed. The dorsal median furrow and the attached muscles cannot be distinguished

and it is not till about three days after hatching that the furrow and attached muscles become clearly differentiated. Being functional for such a short time its complete development does not take place till late in the larval life. It is not till shortly before emerging from its host that the press becomes completely developed as it is not necessary that it should be fitted for spinning during the entire lifetime of the larvae but only for the very short time occupied in the building of its cocoon.

In structure the press differs from that described for Lepidoptera in that the lateral pair of muscles is not present, and from that of the Trichoptera in that each dorsal muscle is single and not divided into two distinct bundles as figured by Gilson.

Functions of the Press.— The functions of the press in the Lepidoptera have been carefully worked out by Gilson and Blanc and there is no doubt that the functions of this structure in the Hymenoptera are similar. These functions may be summed up as follows,—

1. The press modifies and regulates the form and diameter of the two threads.

2. It regulates the layer of "gres" or "gum" which surrounds these threads.

3. By the relaxation of the muscles the chitinous walls, on account of their elasticity, contract and hold the thread immovable as in a vise.

Gilson attributes to the press another function, that of forcing the thread to the exterior when by accident or voluntarily the thread is broken in the spinneret. This is denied by Blanc who holds that the contraction of the muscles of the press, distending its lumen to the fullest extent, together with the pressure upon the contents of the gland due to the elasticity of its walls, and the general muscular contractions of the body, serve to force the thread to the exterior when broken in the spinneret or even in the conducting tube.

In the case of *Apanteles glomeratus* we do not think the press possesses the latter function attributed to it by Gilson, inasmuch as the pressure exerted by the elastic walls of the abdominal portion and the general contractions of the somatic muscles along with that of the muscles of the press, seem to us a more correct explana-

tion of how the thread is first forced to the exterior and also how it is extruded when broken.

It is not necessary for us to describe the mechanism of spinning as that has been fully done by Blanc and Gilson for the Lepidoptera and their descriptions serve equally well for the hymenopterous larvae. The method of spinning the cocoon in *Apanteles glomeratus* has been well described and figured by Reaumur.

The Spinneret.— From the press a short chitinous tube leads to the spinneret (*sp.* Figs. 28, 29 and 30). The lumen of this tube gradually widens as it approaches the exterior (Figs. 29 and 30). The entire length of the common duct is .875 mm., of which the press occupies .4 mm. The spinneret is situated just beneath the buccal cavity and consists of two small chitinous projections directed cephalo-dorsad (Fig. 28, *sp.*).

Functions of the Different Parts of the Silk Gland.—*Abdominal Division.* As previously pointed out the abdominal division of the silk glands consists, in the young larvae, of two pairs of straight cylindrical tubes lying on each side of the alimentary canal. As the larvae grow these parts become active, their lumina become gradually distended with the secreted product till, in the mature forms, the glandular walls are so thin as to warrant the assertion that they have practically ceased to secrete and are merely reservoirs for the accumulated product.

The question as to whether the "gres" or "gum" is secreted by one particular region of the gland and the silk by another is still unsettled. Gilson in 1890 and again in 1894 came to the conclusion that both are secreted throughout the gland; and that the silk, properly speaking, is the result of a selection effected in the layer of secreted product lying next the internal face of the cells. Whether this process of selection is a chemical phenomenon or merely a physical separation, he does not attempt to decide. From a study of several series of sections he concludes that the outer or cortical layer of the secretion is granular in appearance and has special affinity for coloring agents. Neither of these conclusions is absolute since he did not find them to hold true in all cases.

Blanc, '89, p. 24, states that "The silk secreted in the posterior part of the gland is discharged continuously into the reservoir and, on its arrival there, it is surrounded by a new material which is

formed in this region. This substance is the 'gres.'" He considers (pp. 27–28) the "gres" as nothing more than the peripheral layer of silk oxidized in the reservoir, the oxidation being due to the presence of a large number of tracheae in this region. .

In the abdominal portion of the silk glands of *Apanteles glomeratus* the secretion appears as a hyaline, faintly staining product. Fixation in Flemming's solution and staining with iron haematoxylin gives it a greenish color, the peripheral portion often being black. In the anterior part of the abdominal portion the peripheral layer is always stained black. Safranin colors the entire secretion salmon color, the peripheral layer always more deeply, especially in the anterior part of the abdominal portion. Mayer's acid haemalum and eosin do not color it at all.

Judging from the staining properties of the secretion the conclusion that there is a differentiation between the peripheral layer and the central column appears justified. Whether this peripheral layer is the "gres" or not is a question which we do not pretend to answer.

Thoracic Division. This portion of the gland remains actively secreting much longer than the abdominal division. The characteristic appearance of an actively secreting portion is shown in Pl. 2, fig. 16. The peripheral area often appears less deeply stained and numerous vacuoles are always present.

The character of the secretion in the posterior thoracic division appears similar to that of the abdominal portion except that the peripheral layer has a greater radial diameter and that vacuoles are generally more numerous. It also takes the same characteristic colorations.

The anterior and middle thoracic portions secrete a somewhat different product. The character of the cells of the middle portion would indicate that such is the case here at least. Fixation in Fleming's solution and staining with iron haematoxylin gives to this division a very characteristic appearance. The cytoplasm is filled with rather large rounded black granules thus easily differentiating this portion from the other two thoracic divisions. The nature and function of these granules we were unable to determine. In similarly treated glands many identical black granules are seen near the internal surface of the cells just within the internal membrane. These granules are present in all parts of the gland except the first thoracic division (Pl. 1, figs. 10 and 12).

The dense secretion covering the inner surface of the 1st thoracic portion indicates that this is its own peculiar product and not that of the following division. This secretion appears closely striate in a radial manner. Acid haemalum and eosin do not color it; iron haematoxylin, safranin, and Grenacher's borax carmine stain it but slightly. The central column of silk, however, is more densely stained with iron haematoxylin and safranin.

As the glands of Philippi are not present it is only speculation to suppose that the secretion of the second thoracic portion may be of a nature similar to that of these glands in the Lepidoptera. The function of the product of the glands of Philippi is not definitely known. Nearly all workers differ in their conclusions in regard to this question. The conclusion of Blanc, '91, and Berlese, '06, based upon the experiments of Robinet, '39, seems the most logical. These authors consider its function that of lubricating the thread which is to pass through the press.

The fact that the thread, in *Apanteles glomeratus*, begins to take on its definite form at the posterior end of the 1st thoracic portion might indicate that the secretion of the 2nd division had a coagulating effect upon the silk and "gres."

Summary

1. The silk glands of *Apanteles glomeratus* differ from those in the Lepidoptera and Trichoptera in that there are four tubes in the abdominal region. Their histological structure is similar to that of Lepidoptera and Trichoptera but differs markedly from that described for the tenthredinid larvae.

2. In immature larvae the epithelial cells of the whole producing region are actively secreting. Numerous vacuoles are present in these secreting cells, especially near the periphery.

3. In glands fixed in Flemming's solution and stained with iron haematoxylin there are present, near the inner margin of the secreting cells, many black rounded granules. These are very abundant in the 2nd thoracic portion and absent in the 1st thoracic portion. Their nature and function we were unable to determine.

4. In mature larvae the abdominal division becomes greatly

distended and nearly fills the entire body cavity. It is probable that this portion now acts merely as a reservoir and that its cells have ceased secreting.

5. The glands of Philippi are absent and it is probable that the second thoracic portion performs the functions of these glands.

6. The press is well developed. It differs from that of the Lepidoptera in that the lateral pair of muscles is absent, and from that of the Trichoptera in that there is a single pair of dorsal muscles rather than two distinct pairs.

7. The product of the gland is a double thread as in the Lepidoptera and Trichoptera.

CORNELL UNIVERSITY
Ithaca, N. Y.

BIBLIOGRAPHY

BERLESE, ANTONIO.

1907. Gli Insetti, loro organizzazione, sviluppo, abitudini e rapporti coll'uomo. 1907, vol. 1, pp. 521–523.

BORDAS, L.

1895. Appareil glandulaire des Hymenopteres. *Ann. Sci. Nat. Zool.*, 1895, vol. 19, pp. 12–20.

CARRIÈRE AND BÜRGER.

1897. Die Entwicklungsgeschichte der Mauerbiene (Chalicodoma muraria Fabr.) im Ei. *Nova Acta Acad. Leop. Car.*, 1897, vol. 69, No. 2, pp. 342–350.

CHOLODKOVSKY, N.

1895. Entomotomische Miscellen, I. Ueber die Spinndrüsen der Tenthredinidenlarven. *Horae Soc. Ent. Ross.*, 1895, vol. 29, pp. 145–149, pl. 2.

1901. Ueber den Spinnapparat der Lyda-Larven. *Allgem. Zeit. f. Ent.*, 1901, vol. 6, pp. 17–19.

ECKSTEIN, K.

1890. Zur Biologie der Gattung Lyda. *Zool. Jahrb.*, 1890, Abth. f. Sys. 5, p. 427, pl. XXXV.

DE GEER, K.

1752–'78. Memoirs pour servir a l'histoire des Insectes. Stockholm.

GILSON, G.

1893. On Cytological Differences in Homologous Organs. *63rd Rept. Brit. Ass. Adv. Sci.*, 1893, pp. 813–816.

HENNEGUY, L. F.
1904. Les Insectes, 1904, p. 466.
KIRBY AND SPENCE.
1828. An Introduction to Entomology. 1828, vol. 3, p. 125.
KOLBE, H. J.
1893. Einführung in die Kentniss der Insekten. 1893, p. 623.
NEWPORT, G.
1852. Anatomy and Development of Certain Chalcididae and Ichneumonidae, compared with their special economy and instincts. *Trans. Linn. Soc. Lond.*, 1852, vol. 22, pp. 61–67.
PIKEL, V.
1896. Zur Frage über die Spinndrüsen der Tenthrediniden-larven. *Horae Soc. Ent. Ross.*, 1896, vol. 30, pp. 122–128, Taf. VIII.
POLETAJEW, N.
1885. Ueber die Spinndrüsen der Blattwespen. *Zool. Anz.*, 1885, pp. 22–23.
RAMDOHR, K. A.
1811. Abhandlung über Verdauungswerkzeuge der Insecten. 1811, pp. 58–65 and p. 143.
SEURAT, L. G.
1899. Étude des Hyménoptères Entomophages. *Ann. Sci. Nat.*, 1899, (8) 10, p. 62.
WESTWOOD, J. O.
1840. Classification of Insects. 1840, vol. 2, p. 78.
PEREZ, C.
1901. Histolyse des tubes de Malpighi et les glandes séricigène chez la Fourmi rousse. *Bull. Soc. Ent. Fr.*, 1901, pp. 307–310.
WHEELER, W. M.
1898. The Embryonic Development of the Wall Bee (Chalicodoma muraria Fab.). *Am. Nat.*, 1898, vol. 32, pp. 794–798. A review of Carrière and Bürger's work.

EXPLANATION OF THE FIGURES.

Fig. 1, pl. 1.— Optical section of a young larva shortly after hatching, showing the arrangement of the silk glands. (*s. g.*). ×

Fig. 2, pl. 1.— Longitudinal section of a young larva about six days old. The silk glands have not yet become much convoluted. × 37.5.

Fig. 3, pl. 1.— Mature larva showing the enormous increase in the size of the silk glands (*s. g.*). × 12.5.

Fig. 4, pl. 1.— Longitudinal section of a mature larva. × 12.5.

Fig. 5, pl. 2.— Cross section of a young larva (about one day old) in the thoracic region. × 130.

Fig. 6, pl. 2.— Cross section of a mature larva in the thoracic region. × 37.5.

Fig. 7, pl. 2.— Cross section of a young larva (shortly after hatching) in the abdominal region. × 130.

Fig. 8, pl. 2.— Cross section of a mature larva in the abdominal region. × 37.5.

Fig. 9, pl. 1.— Cross section of the posterior end of one of the tubes of the abdominal division of the silk glands. From a larva just hatched. × 267.5.

Fig. 10, pl. 1.— Cross section of the same portion of the gland as in Fig. 9 but at a later period of the larval life. × 267.5.

Fig. 11, pl. 1.— Cross section of the same portion as shown in Figs. 9 and 10 but from a mature larva. × 267.5.

Fig. 12, pl. 1.— Section of a portion of the glandular wall of the abdominal division showing presence of vacuoles (v) and radiating trabeculae in the cytoplasm. × 260.

Figs. 13, 14, and 15, pl. 2.— Cross sections of the third thoracic portion at different periods of the larval life; Fig. 13 shortly after hatching, Fig. 14 at a later period, Fig. 15 from a mature larva. × 267 5.

Fig. 16, pl. 2.— Section of a portion of the 3rd thoracic division showing numerous vacuoles (*v*) near the periphery of the cells. From an immature larva. × 260.

Fig. 17, pl. 2.— Section of portion of the 3rd thoracic division in a mature larva, showing the great thinning of the glandular walls. × 260.

Fig. 18, pl. 1.— Cross section in the region of the 2nd thoracic portion. From a larva about two days old. × 260.

Fig. 19, pl. 1.— Cross section of the 2nd thoracic portion from a nearly mature larva. × 260.

Fig. 20, pl. 1.— Section of a portion of the 2nd thoracic portion, showing numerous vacuoles (*v*) near the periphery of the cells. × 260.

Fig. 21, pl. 1.— Union of the 2nd and 3rd thoracic divisions. × 260.

Fig. 22, pl. 1.— Surface view of the cells of the 2nd thoracic portion. × 260.

Fig. 23, pl. 1.— Cross section of the 1st thoracic division immediately behind the conducting portion. × 260.

Fig. 24, pl. 3.— Longitudinal section of the point of union of the 1st and 2nd thoracic portions. × 267.5.

Fig. 25, pl. 3.— Cross section of one of the conducting branches. × 260.

Fig. 26, pl. 3.— Cross section of the common duct just behind the press. × 260.

Fig. 27, pl. 3.— Cross section of the press, showing the muscular attachment; *d. m.*, dorsal muscles; *v. m.*, ventral muscles. × 260.

Fig. 28, pl. 3.— Longitudinal section of the press, showing the position of the dorsal and ventral muscles, *s. t.*, silk thread passing through the press to the spinneret. × 260.

Fig. 29, pl. 3.— Same as Fig. 28, but showing the attachment of the muscles directly to the chitin of the conducting tube. × 267.5.

Fig. 30, pl. 3.— Longitudinal section of the press, of one of the conducting branches, and of the beginning of the 1st thoracic portion. *a.*, point of union with the conducting branch of the opposite side. × 267.5.

Fig. 31, pl. 3.— Surface view of a cell and its nucleus, from the abdominal portion. From a larva nearly four days old. × 260.

Fig. 32, pl. 3.— Surface view of a cell and its nucleus, from the anterior end of the 2nd thoracic portion of a mature larva. × 260.

Fig. 33, pl. 3.— Surface view of a cell and its branching nucleus, from the posterior portion of the 3rd thoracic division of a mature larva. × 260.

Fig. 34, pl. 3.— Portion of a cell and its nucleus, from the abdominal division of the glands of a nearly mature larva. × 260.

List of Abbreviations

a. c., alimentary canal.
b. c., buccal cavity.
b. m., basement membrane.
br., brain.
c. d., common conducting tube.
ch., chitin.
co. l., cortical layer.
d. m., dorsal muscle.
e. d., conducting tube.
f. b., fat body.
gr., "gres" or "gum."
ht., heart.
in., intima.
int., intestine.
hyp., hypodermis.
l., lumen.
m., muscle.
m. t., Malpighian tube.
n. c., nerve cord.
nu., nucleus.
ov., ovary.
pr., press.
s., silk.
s. g., silk gland.
sp., spinneret.
s. t., silk thread.
tr., trachea.
v., vacuole.
v. m., ventral muscle.
1st. t., 1st or anterior thoracic.
2nd. t., 2nd or middle thoracic.
3rd. t., 3rd or posterior thoracic.

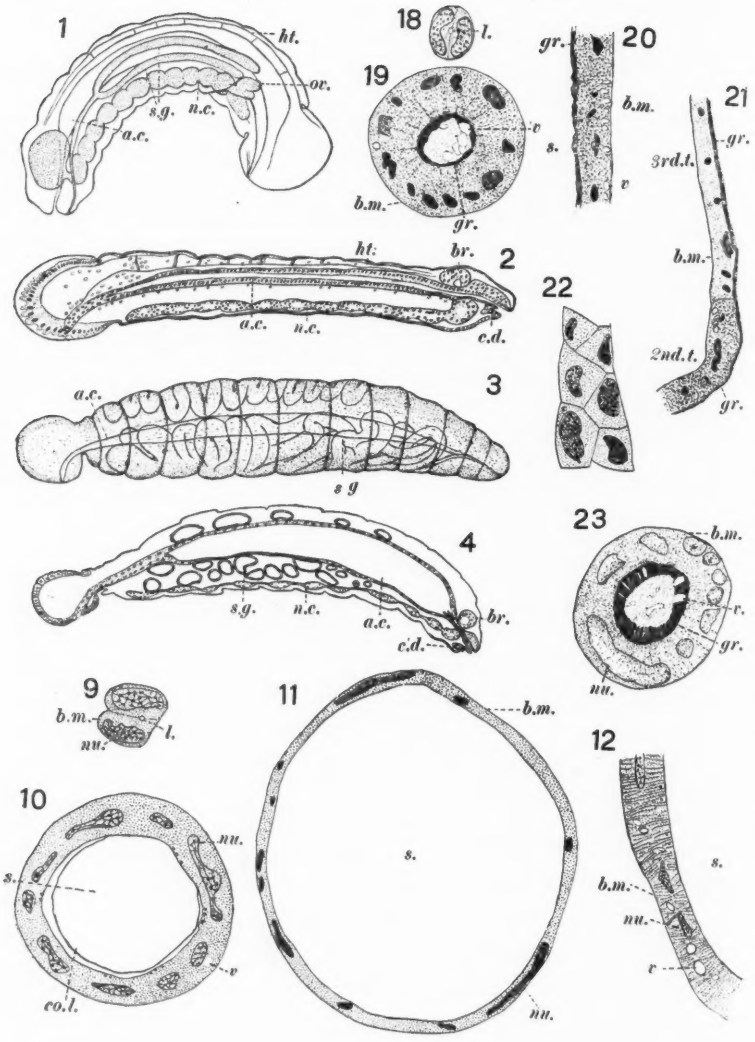

1
ht.
ov.
s.g.
n.c.
a.c.
18
l.
19
v
b.m.
gr.
20
gr.
b.m.
s.
v
21
gr.
3rd.t.
b.m.
2nd.t.
gr.
22
2
ht.
br.
a.c.
n.c.
c.d.
3
a.c.
s g
4
s.g.
n.c.
a.c.
br.
c.d.
23
b.m.
v.
gr.
nu.
9
b.m.
nu.
l.
11
b.m.
s.
nu.
12
s.
b.m.
nu.
v
10
nu.
s.
v
co.l.

PLATE 1

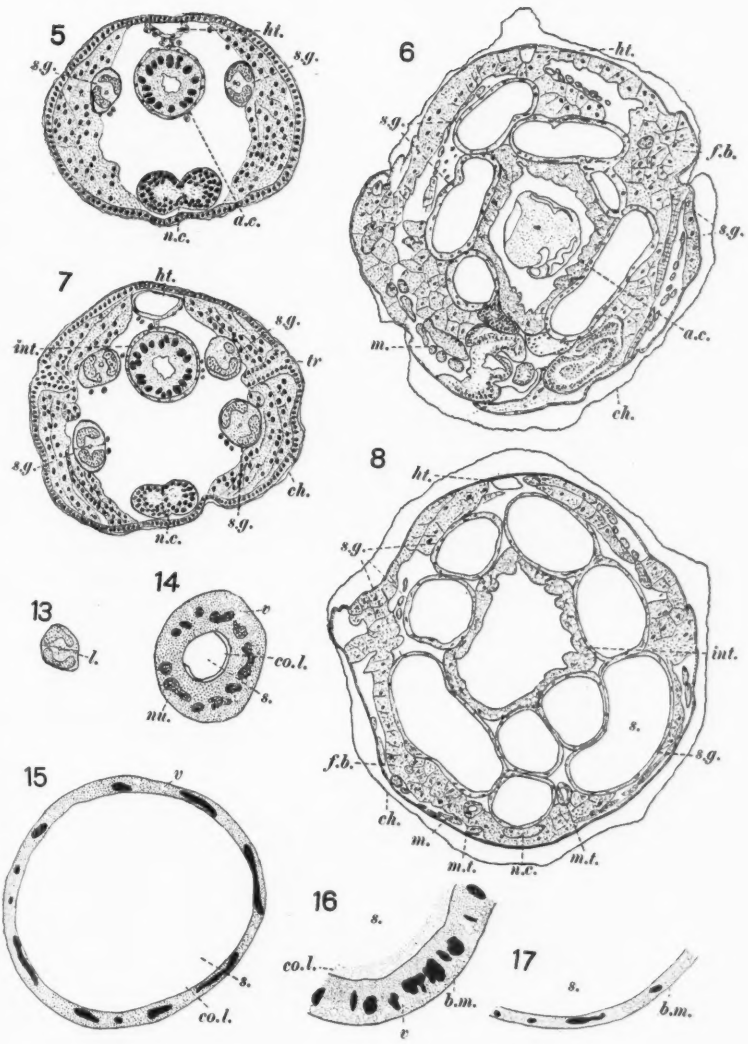
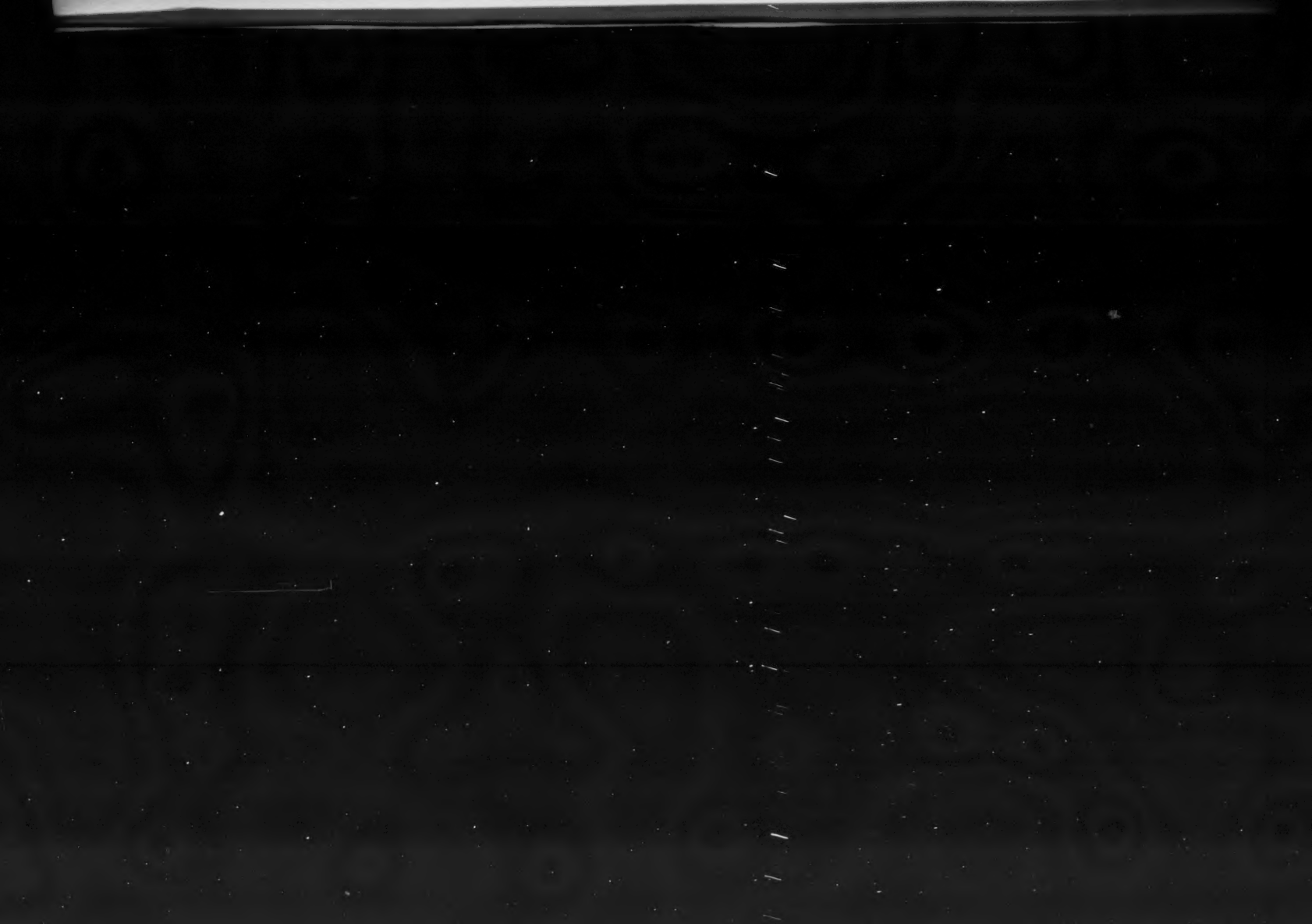

5
ht.
s.g.
s.g.
a.c.
n.c.
6
ht.
s.g.
f.b.
s.g.
a.c.
m.
ch.
7
ht.
s.g.
int.
tr
s.g.
ch.
s.g.
n.c.
8
ht.
s.g.
int.
s.
s.g.
f.b.
ch.
m.
m.t.
n.c.
m.t.
13
l.
14
v
co.l.
s.
nu.
15
v
s.
co.l.
16
s.
co.l.
b.m.
v
17
s.
b.m.

PLATE 2



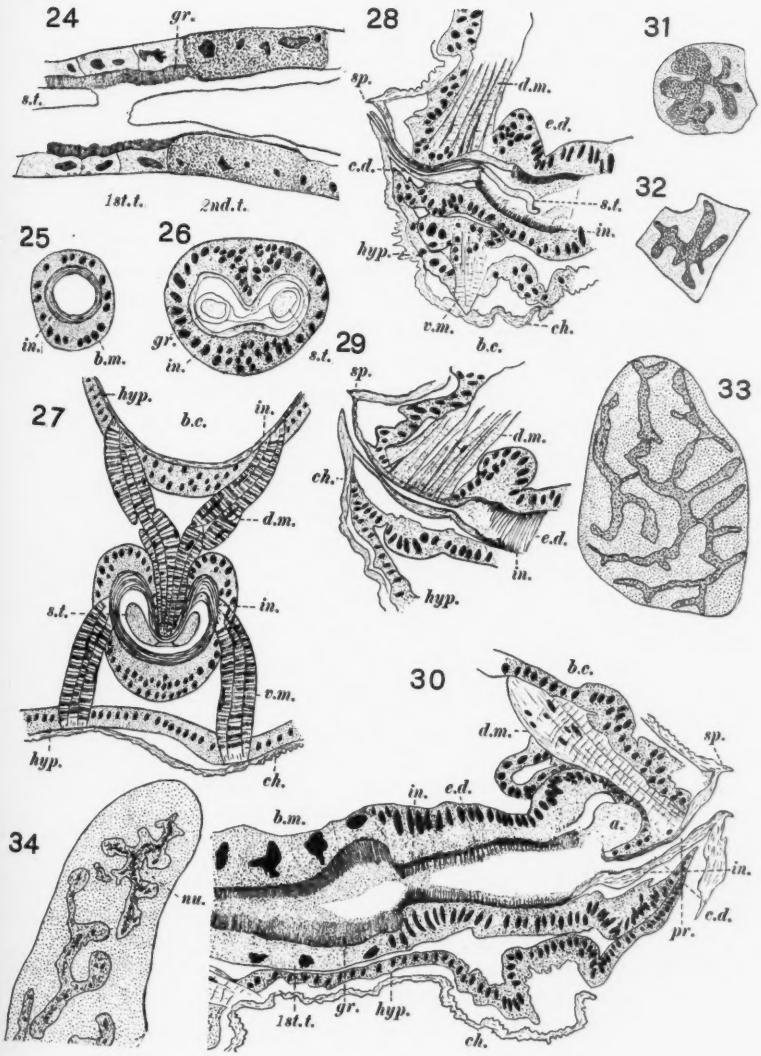

24
gr.
s.t.
1st.t.
2nd.t.
25
in.
b.m.
26
gr.
in.
s.t.
27
hyp.
b.c.
in.
d.m.
s.t.
in.
v.m.
hyp.
ch.
28
sp.
d.m.
e.d.
c.d.
s.t.
in.
hyp.
v.m.
b.c.
ch.
29
sp.
d.m.
ch.
e.d.
in.
hyp.
30
b.c.
d.m.
sp.
in.
e.d.
b.m.
a.
in.
e.d.
pr.
1st.t.
gr.
hyp.
ch.
31
32
33
34
nu.

PLATE 3

THE NEST OF THE KELP FISH

CHARLES F. HOLDER

One of the most interesting fishes found in the great kelp beds along the shores of Southern California is the so-called kelp fish, *Heterostichus rostrata* Girard. In color it closely resembles the sea weed in which it habitually lives. During the past year two adult kelp fishes and a smaller fish of another kind occupied one of the tanks in the Santa Catalina Island Aquarium. The larger kelp fish, a female, was about nine inches in length; the male measured about five inches. I was attracted to them by the savage attacks of the male on the stranger, and investigation showed that he was in nuptial colors and was attending the female. The offending fish was removed giving the kelp fishes the entire tank.

All the colors of the male kelp fish were highly accentuated and brilliant. What had been white was now lavender and silver; the dark angles of the zig-zag barring took on darker tints and were emphasized by countless lines of lavender, yellow, blue and gold; patches of silver, old rose, lavender and white appeared here and there the entire length of the fish, making it a most gorgeous creature. The long vibrating dorsal fin was erect, and the fish was unusually alert as if sensible of the importance of the situation and its responsibilities.

In the tank were several small bunches of a deep maroon seaweed four or five inches high; and as I watched the female, large and heavy with spawn, she approached the weed and appeared to examine it, passing around it several times. Then I saw that her ventral surface was pressed against the weed and that its branches were being caught together by a viscid pure white cord having the diameter of a thick thread. It clung tenaciously to every branch it touched. Along the cord were large numbers of small eggs. When four or five inches of the cord had been attached, the fish would rest, the male taking her place and hovering over the eggs which he guarded with a viciousness altogether unexpected in so small a fish. He withdrew when his mate resumed egg-laying.

She frequently pushed her way through the clump of weed but more often passed around it, the silken tenacious cord binding it together in a globular or oval mass about the size of a hen's egg. The entire nest shown in the photograph was formed in about two hours, the fish dropping to the bottom of the tank after each effort and lying there for ten or twenty minutes.

The accompanying photograph of probably the first nest of Heterostichus to be recorded was made under my direction by

Charles Ironmonger, of Avalon, Cal. It was necessarily taken under cover and through glass and water, all efforts being directed toward having the nest in focus. The head of the female fish shows indistinctly below. Although the photograph was so successful that the eggs within the strands could easily be seen with a hand lens, there was no indication of the beauty of the pure white nest among the rich purple and lavender weeds.

PASADENA, CAL.

NOTES AND LITERATURE

GENERAL BIOLOGY

Specific Characters in Early Embryos.— In a recent contribution to the *Naturalist* it is asked if "by and by we are going to find specific characters in the eggs of animals as well as in their adult condition." In the seventeenth century this was believed to be true, since the egg was supposed to contain in miniature the adult form to which it should give rise. Early in the nineteenth century, however, it was thought that the embryos of the higher animals passed successively through stages corresponding with the adults of lower forms. With the theory of evolution, it began to be considered that the early embryos in different groups of animals were identical and that specific characters were late acquisitions. A few interesting expressions of this opinion are as follows:

"Embryology has revealed the strange resemblance which exists, at the beginning of their formation, between the embryos of different vertebrates; it has shown how each embryo before taking its final form hesitates, so to speak, between different specific forms."[1]

"Take, for example, the case of the highest organism, Man.... When his animality becomes established, he exhibits the fundamental anatomical qualities which characterize such lowly animals as polyps and jelly fish. And even when he is marked off as a vertebrate it cannot be said whether he is to be a fish, a reptile, a bird, or a beast. Later it becomes evident that he is to be a mammal; but not till later can it be said to which order of mammals he belongs."[2]

"The embryo of a mammal at the stage which represents a gill-bearing vertebrate, in all cases which I have examined, ranges from one third of an inch to an inch in length; the former size belongs to the smaller kinds, the latter to the larger. Know one, know all; one diagram would represent all, one description serve for all."[3]

"The careful investigation and comparison of embryos of man and

[1] Cresson, A. Les bases de la philosophie naturaliste. Paris, Félix Alcan, 1907. p. 64.

[2] Romanes, G. J. Darwin, and after Darwin. Chicago, Open Court Publ. Co., 1892. p. 119.

[3] Parker, W. K. On mammalian descent. London, Charles Griffin Co., 1885. p. 14–15.

other vertebrates . . . . is highly instructive and discloses to the thoughtful person deeper and weightier secrets than are to be found in the so-called "revelations" of all the religions of the earth. Compare attentively the successive stages of the chick, pig, rabbit, and man shown in the accompanying figure. In the first stage (the upper row), in which the head with the five cerebral vesicles and the gill arches are clearly marked out but the limbs are still wholly absent, the embryos of all vertebrates from fishes to man differ from one another either unessentially or not at all. In the second stage (the lower row), in which the limbs have begun to develop, distinctions between the embryos of lower and higher vertebrates have begun to appear; yet the human embryo even now is scarcely to be distinguished from those of the higher mammals . . . . These are facts the significance of which cannot be overestimated."[1]

As drawings of embryos, the well known figures of Haeckel here reproduced are totally valueless. The front limbs have been transferred to the neck, and the characteristic features by which any one familiar with embryos can distinguish a pig from a rabbit have been wholly overlooked. Although Parker declared that 'one diagram would represent all,' his figure of the embryo mole could not possibly be mistaken for a pig. Moreover the pig at this stage could be distinguished from the rabbit or man by its pancreas alone. The comparative study of embryos to detect generic and specific differences has not been carried far, but from such publications as Keibel's *Normentafeln* of the pig and rabbit it is evident that at no stage in their development is there a confusing similarity in external form.

In place of Haeckel's upper row of figures, those of still younger stages may be substituted, in which the differences are more obvious. The spherical yolk of the hen's egg, the elongated vesicle of the sheep (that of the pig being quite as long but not so slender), the round smooth vesicle of the rabbit and the villous human vesicle are radically different from each other. Since these membranous structures are parts of the embryo they must be regarded as expressions of differences existing at an early stage. Since a given egg cell can produce only one species of animal it must, according to current embryological belief, contain specific characteristics, and if an inheritable peculiarity appears in any adult animal it will modify to some extent the egg cell and every succeeding stage of development. Thus, according to

[1] Haeckel, E. Anthropogenie. 3rd ed. Leipzig, W. Engelmann, 1877, p. 288–289.

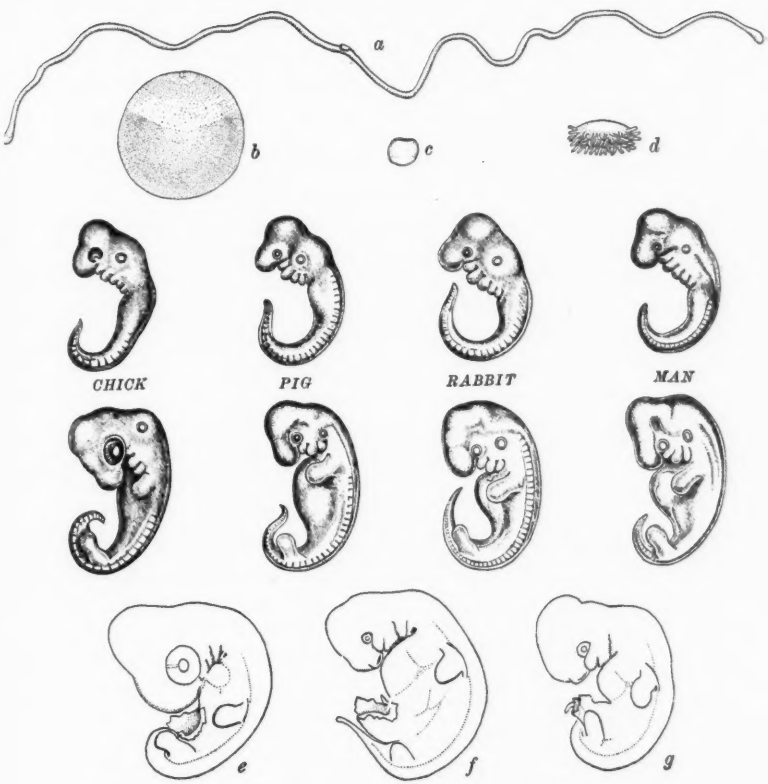


FIG. 1.— The two rows of embryos of the chick, pig, rabbit, and man are from Romanes' copy of Haeckel's figures. The others are:— *a*, sheep, 12 days 2¼ hours, ⅔ nat. size (Bonnet); *b*, chick, 33 hours incubation, ⅔ nat. size; *c*, rabbit, 7 days, × 2; *d*, man, 12–13 days × 2 (Reichert); *e*, chick, 5 days, 8.5 mm.; *f*, pig, 20 days, (?), 9.0 mm.; *g*, rabbit, 12½ days, 8.5 mm.

Hertwig, there are as many kinds of egg cells as there are species or kinds of animals or plants. Morgan, after an interesting historical consideration of the question, says,— "I should not expect to find the embryos of any two species identical at any stage in their development, but at most there might be a close resemblance between them."[1]

[1] Morgan, T. H. Evolution and adaptation. New York, The Macmillan Co., 1903, p. 74.

Montgomery states that two species are as distinct in the egg-cell stage as in any later one, "no matter whether the differences are as perceptible or not."[1] Such a statement, however, evades the question whether or not embryos of related species can actually be distinguished from one another.

The four suborders of rodents, represented by the squirrel, mouse, guinea pig, and rabbit respectively, according to Lee may be distinguished at very early stages. His studies do not enable him as yet to recognize the genera of one suborder,— namely the gophers, prairie dogs, squirrels, and chipmunks — until the embryos are far advanced. Differences in tunicate eggs of closely related genera have, however, been recorded by Conklin, and McClung can distinguish several species in one genus of grasshoppers by the chromosomes of their germ cells.

F. T. L.

ZOOLOGY

New Text Books of Zoology.— The most important service that biology can render to students is to train their reason and their power of observation, and to free them from a too deep reverence for authority. This service can also be performed by the other natural sciences, physics and chemistry, which are commonly included in the curricula of high schools but which require expensive apparatus beyond the reach of many schools. Biology, however, can be profitably taught with so slight an equipment that every school can afford to undertake to teach botany or zoology, or both. The teaching of biology has often failed to yield the results that educators have expected. This is so because teachers too often yield to the temptation to tell the students the facts and theories which they ought to learn by their own efforts, instead of teaching them how to discover, to classify, and to draw proper conclusions.

Professor Glenn W. Herrick, of the Mississippi Agricultural College has endeavored to meet the needs of the high school of limited means whose students will, as a whole, have no further instruction in biology. He presents to such students a laboratory guide containing directions for the examination (we can scarcely say for the dissection) of some-

[1] Montgomery, T. H. The analysis of racial descent in animals. New York, Henry Holt and Co., 1906. p. 192.

thing more than twenty species of vertebrates and invertebrates, together with questions, the majority of which appear to be answered by the context, the remainder by the companion text book.[1] This method seems to us unwise and the book is apparently less useful than Kingsley's *Elements of Comparative Zoology* (2nd. ed., Henry Holt and Co., 1904). The latter is a cheaper book which gives facts that are otherwise inaccessible to the student and asks questions which can be answered without appeal to costly apparatus, about easily obtained and inexpensive animals. The answers, the student must gather while learning both to find and arrange facts and to draw right conclusions. A more extensive work is that of Linville and Kelly; their *Text Book in General Zoology* and *Guide for Laboratory and Field Work in Zoology* (Ginn. and Co., 1906) give facts and suggestions, especially for the reading of original articles, together with necessary deductions; and ask most interesting and suggestive questions which the student must answer from his own work. The conscientious use of any of these books will give the student about the same facts, but Kingsley, and Linville and Kelly, compel the student so far as a book can do so, to observe and think, which is the most desirable service to the memory-laden youth. It really makes little difference how many facts are given to a student, whatever his future may be; the method of study is of primary importance.

Some of Professor Herrick's diagrams are not wholly correct. For example Fig. 70, which is very much like the excellent figure of a male crayfish in McMurrich's *Invertebrate Morphology* (Fig. 168), is labelled as a female. It is the sperm duct, and not the oviduct as in Herrick's figure, which opens at the base of the last thoracic limb. The following statement from page 33 of the text book is an example of defective fact and theory,— "It may seem strange that the oldest animals (Protozoa) are the simplest, but it is true. It is probably due to the fact that these animals have always lived in the water and the water is probably not very different today from what it was ages ago. Hence there has been nothing to bring about change in these animals, and they have remained much the same." It is needless to say that Protozoa or even Amoebae are not confined to the water and that very many highly developed animals have been evolved in water.

For more advanced students Dr. Gilman A. Drew, Professor of

[1] Herrick, G. W. *Laboratory Exercises in General Zoology.* New York, American Book Company, 1907. 12mo., 110 pp. 60 cents.

Herrick, G. W. *Text Book in General Zoology.* New York, American Book Company, 1907. 12mo., 386 pp. $1.20.

Biology at the University of Maine, has written a *Laboratory Manual of Invertebrate Zoology*.[1] This book is essentially like Bumpus' *Laboratory Course in Invertebrate Zoology*, the first edition of which appeared fifteen years ago, and both are the result of the teaching of zoology at the Marine Biological Laboratory at Woods Hole. The later book, however, differs from the earlier in the addition of tables of classification, an index and a glossary, as well as in the number and length of the directions for dissection.

The second edition of Bumpus' book (1893) gives directions for the dissection of 31 species in 141 pages, while Drew deals with 90 species in 174 pages or, if we exclude the 16 pages devoted to classification, in 158 pages.

This large increase in the number of species without a corresponding increase in the size of the book does not indicate superficiality, as might reasonably be inferred, but is due to the desire to show the student something of the range of modifications in structure and of the marvellous adaptation to environment found among invertebrates. A good example of this is seen in the treatment of the annelids. Nereis and Lumbricus are each given a moderately full description: the specialization of the swimming and sensory organs are emphasized in the former; the nephridia, reproductive organs and musculature in the latter. Other genera show budding; the formation of scales, tubes and shells of various form and material; types of gill; and the differentiation of the body into two or three regions. This is really splendid and we hope that our fear is unwarranted that internal anatomy is given too small a place. This fear is in a measure justified by the fact that the coelom of echinoderms is not mentioned, that of mollusks is indicated only by references to the pericardium and, in the squid, to the ovary "inclosed in a capsule from which the oviduct leads."

The wealth of living material demanded by the book ought to limit its use to marine stations or to schools near the ocean. The glossary is not perfect but is useful. The term nephridium is not defined and the excretory organ of molluscs, which is a nephridium, is called in the text a kidney; and the definition of the kidney is,— "Frequently applied to the excretory organ of an invertebrate." The hypophysis is defined as "a ventral projection from the brain of Chordata."

The book has excellent features and in the second edition which will be demanded soon, minor faults will be eliminated. The book

[1] Drew, G. A. *A Laboratory Manual of Invertebrate Zoology*. Philadelphia, W. B. Saunders Co., 1907. 12mo., 201 pp. $1.25.

will probably serve another decade as well as Bumpus' book has served students of zoology for the past ten years.

LEONARD W. WILLIAMS

Books of Nature Study.— The American Book Company is issuing a series of "Eclectic Readers" for lower grammar school grades. These include *The Trail to the Woods*[1] by Clarence Hawkes, and *Half Hours with Mammals*,[2] by Charles F. Holder. The former is chiefly a collection of hunting stories. It tells of foxes who "stop a moment to consider" and who have learned to place a wounded foot in cold water "to draw out fever and pain." With the humanizing of the foxes there is a cold-blooded account of their destruction — "As the club said, 'They were just old enough to play nicely.' By seven o'clock the pelts of two of them were dangling from the pockets of lucky hunters." This is not good reading for children.

The book by Dr. Holder in some respects suggests Wood's Natural History. It is intended for intermediate grades. The student is advised not to accept the reports of "honest men and women" who impart to animals such traits as "would astonish the bear, fox and others could they read the English language"; but the author states that animal intelligence differs from human intelligence only in degree. His frequent references to his own observations, particularly of Californian animals, form a considerable part of the book. Of the gopher he says,— "I have seen my favorite carnations waving wildly as though an earthquake was shaking them. Then the stalk and flower would disappear, being hauled down into the burrow and eaten." The Reader is fully and attractively illustrated.

Pictures from Nature's Garden[3] is an English book comparable with Bigelow's *Spirit of Nature Study*. It contains reminiscences and stories about children and butterflies, the author being very fond of both. Several of the photographic illustrations refer to mimicry and protective adaptations, which the reviewer believes are interpreted with the simplicity which led Topsy, as described on page 38, to confound frogs' eggs with tapioca pudding. To justify the child's mistake the author presents a photograph of both. After an interesting descrip-

[1] Hawkes, Clarence. *The Trail to the Woods*. New York, American Book Company, 1907. 12mo, 176 pp., illus.

[2] Holder, Charles F. *Half Hours with Mammals*. New York, American Book Company, 1907. 12mo, 253 pp., illus.

[3] Shepheard-Walwyn, H. W. *Pictures from Nature's Garden*. London, John Long, 1907. 8vo, 311 pp., illus. 6 s.

tion of his butterfly-house, a green-house devoted to rearing plants and insects together, he writes as follows;— "In my younger days I myself amassed an extensive collection of butterflies and moths....I have the collection still, and never look upon it without pride. Friends love to gaze upon the Scarlet Tigers, Clouded Yellows and mammoth Death's Heads; white bearded fossils come down from afar and beam upon it — but when all's said and done what else is it but a collection of corpses? Beautiful though they may be to look upon, arranged systematically with pinions outstretched upon the clean white paper — how much more beautiful to gaze upon the living form flashing its gorgeous wings in sunlight, throbbing with the exuberance of *life*!" This is a frank statement from a collector, but one which is characteristic of the times; interest is being transferred from collections to nature itself.

F. T. L.

Birds of Labrador and of the Chicago Area.— The *Birds of Labrador* are well presented by Dr. Charles W. Townsend and Glover M. Allen (*Proc. of the Boston Soc. of Nat. Hist.*, vol. 33, pp. 277–428). In the introduction the authors describe first their visit to Labrador in the summer of 1906; then the topography, the faunal areas, paths of migration, and ornithological history of the region; and finally the bird and egg destruction which in 1833 filled Audubon with "horror and disgust." "Where fishermen are numerous sea birds are very scarce" and the authors hope that "the wonderful nursery for water birds in Labrador will not be entirely depopulated but that sufficient protection for the breeding birds will be given and that speedily, before it is too late."

The introduction is followed by an annotated list of all Labrador birds, and the book concludes with a table showing the approximate number of each species observed by the authors, a bibliography, and a map. This publication (which is sold separately) will be of interest to the large number of students of local birds in eastern United States, for Labrador is the destination of many familiar migrants. It is unusually well written.

The Birds of the Chicago Area are similarly treated by Frank M. Woodruff (Bull. 6 of the *Nat. Hist. Survey, Chicago Acad. of Sci.*, 221 pp.). The introduction contains notes on the favorable localities for studying birds, their migration, the rapacity of collectors, etc. The catalogue of species brings together a large body of facts covering a long period of observation. Sometimes, however, the list of synonyms

occupies more lines than the account of the bird, as with the savanna sparrow and purple martin. An amusing feature of the extensive bibliography is the translation of the titles of newspaper articles into intelligible form, for example,— *Linger in Winter's Lap.* (An account of birds which delayed their migration.)— *Birds of Mystery at Lake Forest.* (Notes on evening grosbeaks.)— The twelve half-tones of birds or bird haunts include a photograph of a colony of great blue herons, twenty miles north of Chicago.

F. T. L.

The Excess of Male Births.— In the May *Naturalist* (vol. 41, p. 303) A. H. Pike discussed the significance of the excess of male births in human offspring, extensive statistics indicating that 106 males are born for every 100 females. In the June issue of the *Proc. of the Cambridge Phil. Soc.* (vol. 14, p. 122) Walter Heape presents the best available statistics for dogs. Among 36,867 pups of registered stock there are 117 males for every 100 females. Of some twenty breeds considered, all showed an excess of males except two, the figures for which were based on limited returns. The excess of males is apparently greater in large breeds of dogs than in small ones. Mr. Heape believes that the *latest* moment at which sex of offspring can be determined is the time of fertilization. However, since nutrition of the parents may alter the sex-determining factors in their spermatozoa or ova, he thinks it possible that the sex of offspring may be controlled, at least to some extent.

F. T. L.

Recent Publications Concerning the Structure of Insects.— *The Wing Rudiments of the Sheep Tick.*— That the wings of the adult insect are present in the larva in the form of disk-like rudiments is a well known fact. Even wingless species, excepting the Thysanura, possess these so-called "imaginal disks" in the larvae, thus indicating descent from winged ancestors. Extending the work of Pratt, '00, Stange,[1] '07, has traced the development and the degeneration of the rudiments of the wings and halteres in the sheeptick, *Melophagus ovinus.*

He finds that in the earlier stages the disks of the wings and the halteres are identical in appearance except that from the first the

[1] Stange, P. Über die Rückbildung der Flügel und Halterenscheiben bei *Melophagus ovinus. Zool. Jahrb. Anat.*, 1907, 24, pp. 295–322. Pls. 27–28.

wing rudiments are the larger. The wings continue to develop until in the late pupal stages they are provided with a chitinous covering bearing bristles. They then degenerate so that there are left in the adult only peg-like vestiges well supplied with nerves, and possibly sensory in function. Previous workers have mistaken these structures for vestiges of the halteres. The latter, however, completely disappear and are replaced by a spiracle.

The Physiology of Metamorphosis.— An important contribution on the subject of the changes which initiate metamorphosis in insects is a brief article by Metalnikoff.[1] Utilizing the method of marking the leucocytes by means of carmine injections he was able to establish beyond question their active participation in the histolytic changes.

The most interesting feature of his work is the discovery that at the beginning of metamorphosis there appear in the blood of the larva specific toxines which apparently poison definite tissues and cells, and thus render them liable to the attacks of the phagocytes. Blood of mature larvae of *Galleria melonella* was injected into young larvae of the same species and led to almost immediate paralysis. For a half hour or longer, depending upon the quantity of blood injected, the subject lay as though dead, and then gradually recovered. Check experiments showed that injection of the blood of young individuals is perfectly innocuous. The toxicity of the blood is manifest two or three days before pupation and disappears about the third day of pupal life, as soon as the course of histolytic change is run, and the building up of new tissues is well under way.

Similar results were obtained from experiments on the silk-worm, but there is brought out the interesting fact that injections of blood of Galleria has no effect on Bombyx and *vice versa*.

Regeneration in Insects.— Przibram[2] has succeeded in the difficult task of rearing to maturity the common European Praying Mantis, and has studied their color variations and their power of regeneration.

He found that this species which in nature is usually green or brown in captivity produced solely brown nymphs and yellow imagos. The number of molts is seven or eight. The color may vary during the nymphal period but this is apparently independent of their surroundings, degree of moisture, or temperature.

[1] Metalnikoff, S. Zur Verwandlung der Insekten. *Biol. Centralbl.*, 1907, 27, pp. 396–405.

[2] Przibram, H. Aufzucht, Farbwechsel, und Regeneration unsrer europäischen Gottesanbeterin (Mantis religiosa L.). *Arch. f. Entwicklungsmechanik*, 1907, 23, pp. 600–614.

The grasping leg is capable of regeneration but on account of the great mortality among the nymphs this is seldom to be observed.

The same investigator, assisted by Werber,[1] has carried on a series of experiments on the power of regeneration in the bristle-tails (Lepismatidae) which on account of the generalized condition of this group are of especial significance.

The authors find that the Lepismatidae show a marked power of regeneration, since antennae, palpi, anal stylets, and legs may be replaced after mutilation. This capability was to be noted even in sexually mature individuals.

In molting, growth phenomena, and power of regeneration the forms studied display a generalized condition in keeping with their low systematic rank, and comparable to what has already been reported for the myriapods and crustaceans.

The Post-embryonic Development of the Mid-intestine in Trichoptera. — The changes undergone by the mid-intestinal epithelium of insects at the time of metamorphosis have been the subject of considerable study during recent years, but in a preliminary paper Russ[2] has brought to light some entirely new facts regarding epithelial replacement in the pupa of the caddice-fly, *Anabolia laevis*.

In the first day of the prepupal stage there begins an active division of the cells in the regenerative centers of the mid-intestine. The new cells extend out under the old larval epithelium which is soon entirely cast off and forms in the lumen of the intestine the so-called larval "yellow body." Meanwhile the new cells have completely clothed the intestine and now through their activity hasten the dissolution of the mass of old tissue.

Thus far the conditions are similar to what have been observed in other insects. The new epithelium, however, does not *in toto* become the definitive lining of the intestine of the adult. By a contraction of the muscles of the mid-intestine and a consequent formation of a ring-like thickening within its lumen its two ends are brought into proximity. The ring of epithelium and muscle is then constricted off, and now forms a second "yellow body" within the definitive mid-intestine which has been formed from only a small portion of the prepupal tissues.

[1] Przibram, H. und E. I. Werber. Regenerationsversuche allgemeinerer Bedeutung bei Borstenschwanzen (Lepismatidae) l. c. pp. 615–631.

[2] Russ, E. Über die postembryonale Entwicklung des Mitteldarmes bei den Trichopteren (*Anabolia laevis* Zett.) *Zool. Anz.*, 1907, 31, pp. 708–710.

The Suboesophageal Body of Insect Embryos.— The question as to the origin and the morphological significance of the suboesophageal body which has been found in certain insect embryos is an open one. Hirschler[1] has studied this structure in embryos of Donacia and has added much to our knowledge of its nature. He finds that it is entodermal in origin and that from an unpaired rudiment at the end of the stomadeal invagination there arise four rounded, paired masses which finally communicate directly with the lumen of the mid-intestine. These persist until at least the third day of larval life,— their further fate has not been studied.

Hirschler's results apparently confirm the theory of Nusbaum and Fulinski, '06, that the suboesophageal body is to be homologized with the hepatopancreas, or glandular diverticula of the mid-intestine, of the Crustacea.

W. A. Riley.

Stridulation Rhythm of Crickets.— According to A. F. Shull (*Can. Ent.*, vol. 39, p. 213), in the chirping of the snowy cricket "exact synchronism is comparatively rare" and exists only between two or three neighboring individuals. Thus two crickets five feet apart were observed to time their chirps in unison as if they heard each other. The rate of stridulation is independent of wing length; in general it increases with rise in temperature, but Dolbear's and Bessey's formulae to express this relation are only approximately correct. Under the same conditions the rate in different individuals varied from 93 to 110 chirps per minute. Except on cool nights, from 600 to 800 chirps are usually performed continuously; one cricket was found to chirp 2,640 times without interruption.

Notes.— Bull. 110 of the N. Y. State Museum, preparatory to a monograph of the Cecidomyiidae, presents descriptions of 203 new species belonging to this group. The Cecidomyiidae, or gall gnats, are dipterous insects from 0.5 to 3.0 mm. in length which produce various leafy galls including the "willow cones." Bull. 109 of the N. Y. State Museum is devoted to the tussock moth and elm leaf beetle, presenting a colored plate of each, and six photographs showing their destructive effects. The gypsy moth and brown tail have not yet invaded New York.

[1] Hirschler, J. Über leberartige Mitteldarmdrusen und ihre embryonale Entwicklung bei Donacia. *Zool. Anz.*, 1907, 31, pp. 766–770.

BOTANY

Plant Geography.— *The Scandinavian flora.* Several naturalists have considered the origin of the biota of the Scandinavian peninsula. During the glacial period most of the higher forms of life must have disappeared, leaving the peninsula to be repopulated by immigrants from other regions as the ice receded. This immigration was early thought to have had two sources: the central European lowlands and the Russo-Siberian region. The biota of the former is supposed to have come in by way of one or more Baltic land connections, and that of the latter is thought to have gained access by way of Finland and northwestern Russia. But besides these a third element, called by Blytt "the Atlantic group" of plants, was discerned, as the flora, especially of the western part, became better known.

This so-called "Altantic" element is discussed by Stejneger (*Smith. Misc. Coll.*, quart. iss., 3:458–513. 1907) from both the zoological and botanical sides. The term "Atlantic" he considers an unfortunate designation for those members of the fauna and flora which occur nowhere in Norway except along the coast between Stavanger and Kristianssund or where they may be shown to have been derived from this secondary center of distribution. This association shows a strong resemblance to the biota of Scotland and northwestern Ireland, and Stejneger thinks that the similarity is not due to parallel development but that it indicates a direct genetic connection between the two. The possibility of the immigration of this element from Scotland across the present expanse of water is considered and the author concludes that in addition to the arguments against this hypothesis offered by plants and lower animals, the presence of mammals offers a finally conclusive proof of a prior land connection between northern Scotland and western Norway. He thinks that certain geological considerations support this theory.

Endemic plants in Ceylon. Willis publishes important contributions to our knowledge of endemism (*Ann. Roy. Bot. Gard. Peradeniya* 3:271–302. 1906; 4:1–15. 1907). Ritigala is an isolated mountain in the north-central province of Ceylon, which, although of no great height, arises abruptly from the plains and forms the highest ground between the central mass of the Ceylon mountain system and the very similar hills of southern India. The nearest hills are forty miles to the

south and the intervening region is dry, and judging from the configuration of the region must always have been so for at least 25 miles of the distance. It is almost rainless except during the season of the eastern monsoon from September to December. The summit of the mountain, however, is bathed in mist and consequently affords an isolated "moist region" vegetation, practically confined to a few acres within 100 vertical feet of the summit which it must have reached by leaping at one bound over the intervening 40 miles of dry lowland that separate it from the Matale hills to the south or over the 280 miles that separate it from the hills of southern India.

A flora of 144 flowering plants and ferns is found at or near the summit. Of these, 41 belong to the dry region and consequently have not had to be transported forty miles to reach the summit. Of the 103 remaining species, 24 have in all probability been introduced by birds; and 49, of which 24 are ferns or lycopods, have evidently been brought by the wind. Thus only 30 remain whose method of introduction is doubtful; these Dr. Willis discusses in detail.

Bearing these facts in mind, we may now turn to the question of endemism. Of the 144 species and varieties of the flora of the summit, 13 are strictly endemic so far as is now known, and 1 other which may perhaps occur in the mountains of southern India, is provisionally added to the list. The distribution of these plants in the groups recognized above is as follows:

	Total	Endemic
Dry Zone Plants	41	1
Carried by Birds	24	1
Carried by Wind	49	3
Doubtful	30	9
	144	14

The conclusion to be drawn from these figures is that: "Endemism, other things being equal, goes in general with difficulty of distribution and with rare arrival at one spot." The author adduces arguments to show that the introduction of seed by birds would be much more common than that by wind, and that the arrival of seed of those forms which have been classed as doubtful would be the least likely of all. A new form arising from a stock which had reached the summit will be less likely to be swamped by crossing with the parent species if the latter arrives very infrequently. Among the dry zone plants the only endemic form belongs to a genus in which the seeds are extremely ill adapted to transportation over long distances. If difficulty of arrival be one of the conditions of endemism, one would expect to find the

greatest number of endemic forms related to species which are rare elsewhere, and this seems to be true in the case of this flora. Indeed it would seem that the endemic forms belong chiefly to families which show the largest number of endemics elsewhere in Ceylon.

In his second paper, Dr. Willis attempts to show that the differentiation of endemic species cannot be due to the action of natural selection on infinitesimal variations. The arguments are:—

The distinguishing characteristics cannot be shown to have any adaptive value. The endemic forms are often associated with the species from which they have probably been derived. They have not supplanted them as they would if evolved by the selection of special adaptations. The distribution of endemics is narrower than that demanded by their environmental conditions, and corresponds rather with that resulting from an origin by mutation.

In conclusion the author remarks:— "The evidence is not so absolutely in favor of mutation as it is against selection of infinitesimal variations, but at present the mutation theory is the only one in the field which can be invoked to explain the facts."

J. Arthur Harris

Lock on Progress in the Study of Variation, Heredity and Evolution.[1] — This attractive little volume contains two introductory chapters on the general conceptions of evolution, one on the theory of natural selection, one on biometry and one on the theory of mutation. The three chapters following these are devoted to a discussion of the results from investigations of hybridization. One of these is essentially an historical sketch of the work of the older hybridists. The two succeeding chapters treat of Mendelism, to the literature of which the author has already made valuable contributions. In chapter ten he discusses the bearing of recent cytological investigations upon the problems of heredity. A final chapter sums up and discusses the general bearing of the subjects treated.

That the author is a mutationist appears from even a casual reading of a few pages. The style is simple and for the most part very clear as are also the diagrams which serve as illustrations. A few excellent half tones, particularly the portraits of Darwin, Galton, DeVries, Kölreuter, and Mendel, add much to the attractiveness of the book. Possibly the author might have found a much more weighty quotation for his closing pages than one from Bernard Shaw.

[1] Lock, R. H. *Recent Progress in the Study of Variation. Heredity and Evolution.* London, John Murry, 1906. xiii + 299 pp.

The work can be regarded only as an introduction to the modern experimental and biometric study of evolution, since much space is devoted to elementary principles, but it is a commendable effort to bring the newer work before a wide circle of readers.

J. A. H.

Notes.— *The origin of the cow-pea* has been investigated by Wight (*U. S. Dept. of Agric., Bur. of Pl. Ind.*, Bull. 102. 1907.) who concludes that this legume is a native of India and the region northwestward to the trans-Caspian district. Its cultivation in that region is very ancient and it also extended to China at an early period. As early as the beginning of the Christian era it was known in Arabia and Asia Minor and was cultivated in at least one of the countries of southern Europe at about the same time. Its introduction into central Europe occurred much later and independently. It seems to have been introduced into the West Indies in the latter half of the seventeenth century and probably reached the mainland during the first half of the eighteenth century.

Statistical Methods.— Elderton[1] has published a small volume treating in detail some of the less generally known biometric methods. Biologists working with the more refined statistical methods will find it very helpful.

The presidential address before the section of Economic Science and Statistics of the British Association (*Rep. Brit. Ass.*, 76: 629–642. York, 1906.) is a plea for scientific method in statistical research. While primarily of interest to students of social problems, statistical biologists will be interested in some of the arguments.

Notes on Economic Botany.— The second volume of the handbook of sugar cane culture and cane sugar manufacture for Java (Handboek ten Dienste van de Suikerriet-Cultuur en de Rietsuiker-Fabricage op Java. Amsterdam. 1906) published by the associated sugar experiment stations of east and west Java, has just appeared. This elegantly illustrated volume is devoted to the animal enemies of the sugar cane and their parasites.

Takeushi (Bull. Coll. Ag. Imp. Univ. Tokyo. 7:465–468. 1907) discusses the chemical composition of the shoots of *Aralia cordata*,

[1] Elderton, W. P. Frequency Curves and Correlation. 1907. London. Charles and Edwin Layton. xiii + 172 pp.

extensively used as food in Japan and now being introduced into the United States. Funatsu (*l. c.*, 469) gives the composition of a chrysanthemum flower used as food. Albahary (Compt. Rend., 145:131–133. 1907) publishes analyses of the fruit of the tomato. Jaffa (Yearb. U. S. Dep. Ag. 1906; 295–312. 1907) considers the value of nuts as food.

Ybarra (Smith. Misc. Coll., quart. iss. 3:428–457. 1907) has done a service to those interested in the natural history of America by publishing an annotated translation of a letter by Dr. Diego Alvarez Chanca, physician to the fleet of Columbus, dated 1494, relating to the second voyage of Columbus. The letter embraces observations made between November 4, 1493, and the last week in January 1494. Of course but little space could be devoted to botanical matters but several of the references to economic plants are of considerable interest.

J. A. H.

The difficulties of botanists in capitalizing specific names are illustrated in "The Flora of the Gulf Biologic Station," recently issued by the Louisiana Board of Agriculture. It refers to *Verbesina Virginica, Commelina virginica, Lycium Vulgare, Eleocharis Mutata, etc. Cassia Chamaecrista* of Gray's Manual is written *Cassia chamaecrista. Ipomoea pes-caprae* may be compared with *Panicum Crus-galli*. Uniform decapitalization would prevent such confusion. This "Flora," which records some twenty-six phanerogams not previously reported in Louisiana — a state which "is to-day almost unknown botanically" — is to be supplemented by further publications. Its author, R. S. Cocks, refrains from naming prematurely several new forms.

PUBLICATIONS RECEIVED

From July 1 to August 1, regular exchanges not included
The year of publication, when not otherwise noted, is 1907

DREW, G. A. *A Laboratory Manual of Invertebrate Zoology.* Philadelphia and London, W. B. Saunders Company, 1907. 12mo, 201 pp. $1.25.— HERRICK, G. W. *Laboratory Exercises in General Zoology.* New York, American Book Company, 1907. 12mo, 110 pp. 60 cents.— HERRICK, G. W. *Text-Book in General Zoology.* New York, American Book Company, 1907. 12mo, 386 pp. $1.20.

BANKS, N. A catalogue of the Acarina, or mites, of the United States. *Proc. U. S. Nat. Mus.*, vol. 32, pp. 595–625.— DANIELS, F. P. The flora of Columbia Missouri and vicinity. *Univ. of Missouri Studies*, sci. ser., vol. 1, no. 2, 318 pp., pl. 1.— FISHER, W. K. The holothurians of the Hawaiian Islands. *Proc. U. S. Nat. Mus.*, vol. 32, pp. 637–744, pls. 66–82. GIDLEY, J. W. A new horned rodent from the Miocene of Kansas. *Proc. U. S. Nat. Mus.*, vol. 32, pp. 627–636, pls. 58–65.— GUZMAN, D. J. La enfermedad del café en el Salvador. *Com. Parasitol. Agric.*, circ. 60, 24 pp., 6 pls.— INDA, J. R. El gorgojo de las Semillas. *Com. Parasitol. Agric.*, circ. 59, 21 pp., 8 figs.— INDA, J. R. El gorgojo de los plantios de Chile, llamado Barrenillo. *Com. Parasitol. Agric.*, circ. 58, 11 pp., 5 figs.— LYON, M. W. Notes on the porcupines of the Malay Peninsula and Archipelago. *Proc. U. S. Nat. Mus.*, vol. 32, pp. 575–594, pls. 54–57.— MORTON, G. E. Ration experiments with lambs. *Wyo. Exp. Sta.*, bull. 73, 18 pp., 12 figs.— NEWLAND, D. H. The mining and quarry industry of New York State. *N. Y. State Mus.*, bull. 112, economic geol. 16, 80 pp.— PILSBRY, H. A. Hawaiian Cirripedia. *Bull. U. S. Bur. Fisheries*, vol. 26, pp. 179–204, pls. 4–11.— TENNEY, A. A. Social democracy and population. *Studies in History, Economics and Public Law*, vol. 26, no. 4, 89 pp.

LELAND STANFORD JUNIOR UNIVERSITY, REGISTER FOR 1906–1907.— NINETEENTH ANNUAL REPORT OF THE MASSACHUSETTS AGRICULTURAL EXPERIMENT STATION.— NINETEENTH ANNUAL REPORT OF THE RHODE ISLAND EXPERIMENT STATION.— TRANSACTIONS OF THE AMERICAN MICROSCOPICAL SOCIETY, vol. 27.— UNIVERSITY OF COLORADO STUDIES, vol. 4, no. 4.— UNIVERSITY OF MONTANA REGISTER, 1906–7.

(No. 488 was issued August 26, 1907.)